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Project 7043

SMALL PROBE VEHICLE STUDY

PERFORMANCE SUMMARY

VOLUME I

Office of Research Analyses
Science and Engineering Analyses Division

OFFICE OF AEROSPACE RESEARCH
UNITED STATES AIR FORCE
Holloman Air Force Base, New Mexico

December 1963

FOREWORD

The small probe vehicle study was initiated by Headquarters, Office of Aerospace Research, who directed the Office of Research Analyses to conduct the study.

The objective of the study is to provide the Air Force with the information necessary to make optimum use of vehicles. The work statement calls for a comprehensive tabulation of missile specifications, a comparison of vehicle performances and a cost and cost-effectiveness analysis including the influence of reliability and payload costs. Specifications and performances advertised by the manufacturers will be confirmed or modified as a result of the analysis and according to the experiences of the users. The results of the study will lead to a subsequent program to define an economic, standardized stable of small probe vehicles.

Volume I, "Performance Summary," is the first of several reports to be published under this program. It contains general vehicle specifications, detailed performances and information on ground support equipment and heating conditions of the most commonly used probe vehicles. A second volume, "Performance Summary," is planned which describes more small probe vehicles of interest to the Air Force. Cost analysis, cost effectiveness analysis and appendices will be presented in additional separate reports.

The information presented and used in this report was collected in the second half of 1962 and through 1963 from missile manufacturers, motor manufacturers, launching sites and government agencies as users in the United States and Canada.

The work was performed under the general direction of Dr. Gerhard R. Eber, Technical Director of the Office of Research Analyses. Task Scientist was Mr. Friedrich H. Utech, Flight Systems, Science and Engineering Analyses Division. Members of the working team who contributed significantly to the project were Mr. Wendell M. Adamson, Dr. Charles E. Barrett, Mr. Hermann F. Borges, Major Roderick W. Clarke, Dr. Fritz W. Hoehndorf, Dr. Harald A. Melkus, Dr. Friedrich G. Penzig and Major Bob L. Whitfield.

ABSTRACT

This report presents technical information on the first group of small probe vehicles considered under this study. It contains general information data, dimensions, weights, performances, comparison of computed performances with data advertised by manufacturers and performances observed in actual flights. Included are specifications for the ground support equipment required and notes on the payload compartment heat transfer conditions for each different vehicle. ( )

Keywords:

Sounding Rockets
Specifications
Performance

This report is approved for publication.

K. W. GALLUP
Colonel, USAF
Commander, Office
of Research Analyses

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INTRODUCTION

This report presents a summary of technical information on the first group of small probe vehicles considered under this study. The vehicles were selected according to their relative importance, frequency of use and availability of data at the time the work was started.

A uniform scheme is used in the arrangement of the information contained in this report. Each vehicle has a different number, which is combined with the page numbers (see Table of Contents). For instance, Page 3-7 means: Vehicle No. 3, Page No. 7. The sequence of pages for each vehicle is always the same.

Page 1: Carries the name of the vehicle.

Page 2: Contains a table with pertinent missile data such as exact designations, number of stages, motors used, maximum performances, reliability and sources of the information.

Page 3: Has information on vehicle history, stabilization, fin alignment, firing sequence and in some cases recommendations for the use of the performance graphs in order to obtain realistic values.

Pages 4 and 5: Show the vehicle assembly, dimensions and weights as well as the configuration of the payload compartment and specifications on the volume available.

Pages 6 and the following pages: Represent a group of performance graphs for three different launch angles and three different payloads. They are arranged in the following sequence:

> Peak altitude-payload performance, peak altitude vs launch angle, altitude vs time, altitude vs range, elapsed times above specified altitudes, peak accelerations, maximum velocities and maximum altitudes of the burning phase and a comparison of calculated, advertised and actual flight performances. Where important, the influence of the coasting time (between stages) on the peak altitude is shown and also the impact ranges of the booster hardware.

The last two pages contain specifications on the ground support equipment required and notes on heat transfer conditions of the payload compartment.

The flight regime chosen for the performance calculations is a very broad one, in order to obtain knowledge on performances in a wide range and to be able to interpolate rather than extrapolate all practical flight conditions. The extreme conditions of the flight regime therefore are in certain cases not realistic and should be used with caution. The limitations are discussed under recommendations for the use of the performance data at the end of this introduction.

The flight performance calculations were conducted under the assumption of two dimensional ballistic trajectories, zero lift conditions, aerodynamically clean payload compartments having no external antennas, spherical non-rotating earth, no wind, and stable vehicles. The aerodynamic drag coefficients have been carefully calculated for every configuration for thrust and coasting conditions. If several payload compartment configurations are shown the calculation was performed with the one designated "standard compartment." The engine thrust was taken from thrust-time curves obtained by motor manufacturers and corrected for ambient pressure. The 1959 ARDC model atmosphere was used.

The weight of the nose cone was included in the vehicle weight. Every additional weight in the payload compartment is defined as "payload" or "net payload."

<u>Recommendations for the use of the performance data:</u>
In order to obtain realistic results, when using the performance graphs, it is necessary to limit the broad flight regime chosen for the computation. The limits are set by: stability properties of the vehicles, structural safety limits, heat transfer conditions, and also range safety regulations.

The parameters having the widest range are launch angle and in some cases payload. The launch angle range considered in the computation is from 70 to 88 degrees measured from the horizon. A survey of actual firings shows that these extreme

angles were never used. The launch angles used range between 75 and 85 degrees. Most of the vehicles were launched under an effective launch angle close to 80 degrees.

Exceptions are the vehicles of the Aerobee family and probes like the Iris which use the Aerobee launching tower. The Aerobee towers are adjustable from 80 to 90 degrees. The survey shows that Aerobee vehicles were launched at angles from 80 degrees to a maximum of 87.5 degrees.

The restrictions in payload weight can be seen in the performance comparison graphs. In many cases the full payload range has not been used in the firings. It can also be seen that manufacturers sometimes show only a part of the payload range in their performance curves and there are cases where two different manufacturers who advertise the same type vehicle offer two different payload ranges.

For realistic results the tables of this report should be used within the limits set by successful firings. This means for launch angles the area between 75 and 85 degrees should be used, and for the Aerobee type vehicles the area between 80 and 88 degrees, unless otherwise recommended in the text on pages 3. As far as payloads are concerned, the experimenter is safe when he stays within the limits of successful firings indicated on the performance comparison graphs.

Should launch angles and payloads which exceed the above limits be desired for some special experiment, it is recommended that the manufacturer be consulted so that stability and structural safety limits of the vehicle are not exceeded.

Changes of the aerodynamic configuration of the payload compartment by adding exterior antennas or by using different shaped compartments, cause changes in performance and should be taken into account.

AEROBEE 150 AND 150A

Aerobee 150 and 150A

VEHICLE DESCRIPTION

Name of Vehicle	Aerobee 150 and 150A
Designation	Aerobee Hi (150-3 Fins, 150A-4 Fins)
Manufacturer	Space General Corp., El Monte, Calif., a Subsidiary of Aerojet General Corp.
Kind of Vehicle	2 Stage, Fin Stabilized Probe Vehicle
First Stage Motor	2.5 KS-18000 (Solid fuel)
Second Stage Motor	AJ 11 - 31 Air Force) AGVL-0113 F Navy) Liquid fuel AJ 60-13 NASA)
Payload-Altitude Capability for 88° Launch Angle	125 lb - 144 N.M. 200 lb - 116 N.M. 300 lb - 91 N.M.
Payload Volume	4.75 cu.ft.
Peak Acceleration	12.7 G's (125 lb Payload 88° L.A.)
Max Velocity	6850 FPS (125 lb Payload 88° L.A.)
Launch Weight, less net payl.	1947.5 lb
Reliability	87%
Users	Air Force, Navy, Army, NASA Applied Physics Laboratory (John Hopkins)
Sources	Aerojet, AFCRL, Chance-Vought, NASA Performance Calculations AFMDC, Analog Computation Branch

Aerobee 150 and 150A

The Aerobee 150 and 150A are proven vehicles with more than 130 firings together. The Aerobee 150A is the 4 finned version of the 3 finned Aerobee 150. Fins have been redesigned and propellant tanks transposed resulting in slightly improved aerodynamic characteristics of the Aerobee 150A.

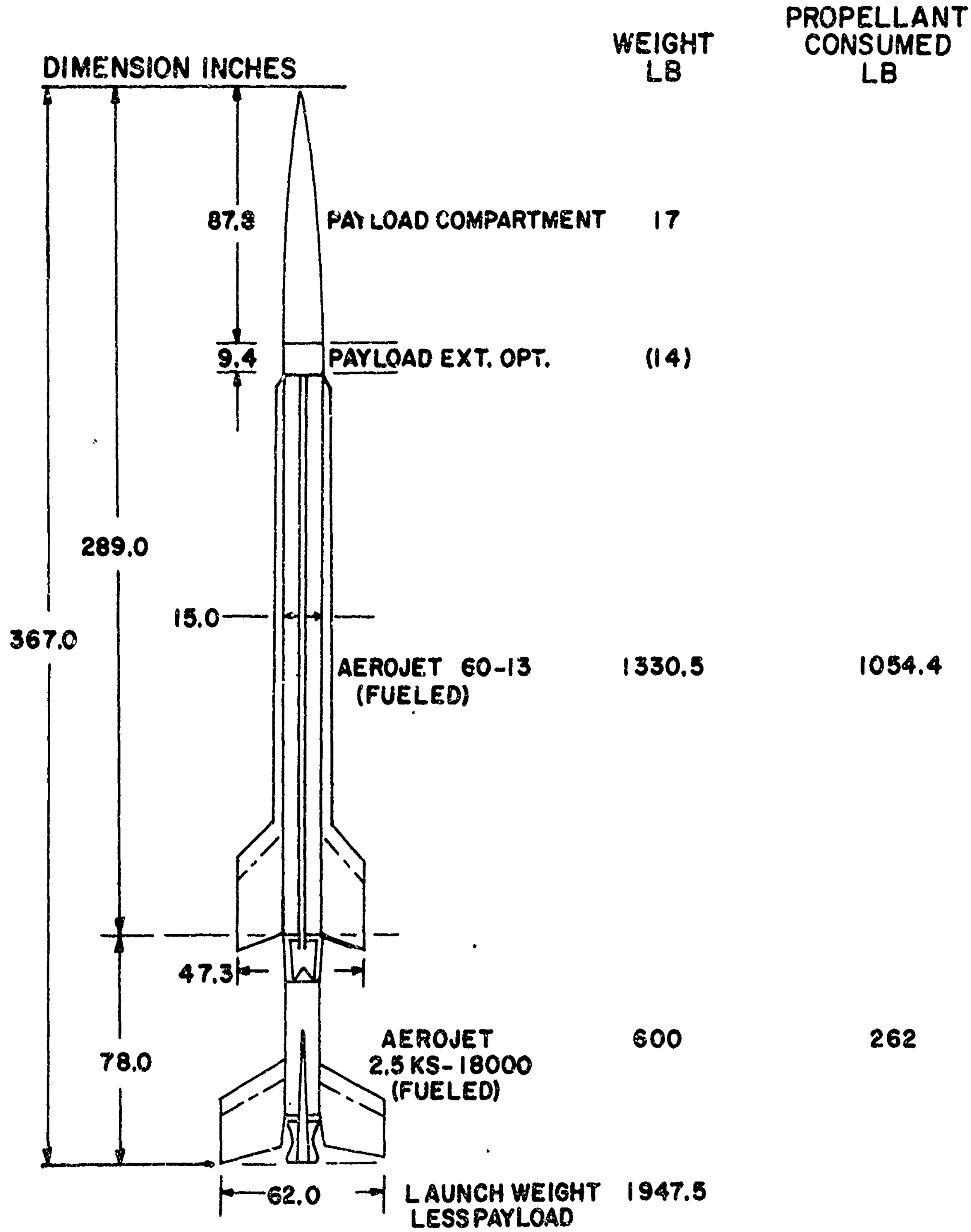
As the peak altitude performance of the Aerobee 150A for the same payloads proved to be only 1.5% to 2.5% better than the one of the Aerobee 150, this performance calculation was performed only for the Aerobee 150A. However, the two vehicles need different launching towers, details can be seen under ground support equipment.

Using the presently available towers the Aerobees cannot be launched below 80° launch angle.

The booster fins are installed under an angle of $2^{\circ}30'$ to impart a roll rate as the vehicle leaves the tower. The second stage fins are adjustable from $0^{\circ}0'$ to $0^{\circ}20'$ for a desired roll rate.

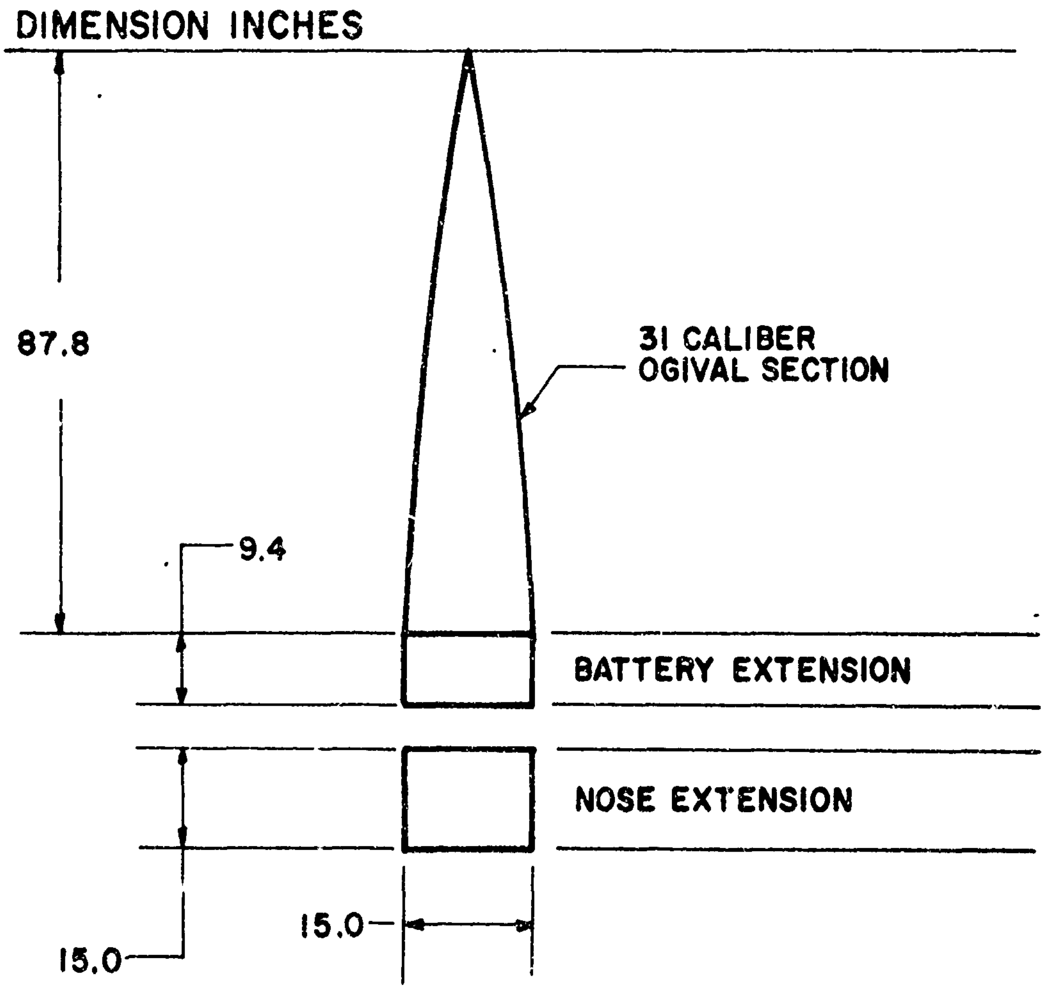
The firing sequence is as follows: the burning time of the booster is 2.5 seconds. After 0.3 seconds of booster burning the second stage is ignited and both burn simultaneously until booster burnout. The burning time of the second stage is 52 seconds. The total burning time, taking into account the overlapping, amounts to 52.3 seconds.

AEROBEE 150 AND 150A
ASSEMBLY, DIMENSIONS AND WEIGHTS
PAYLOAD 125-300 LB.



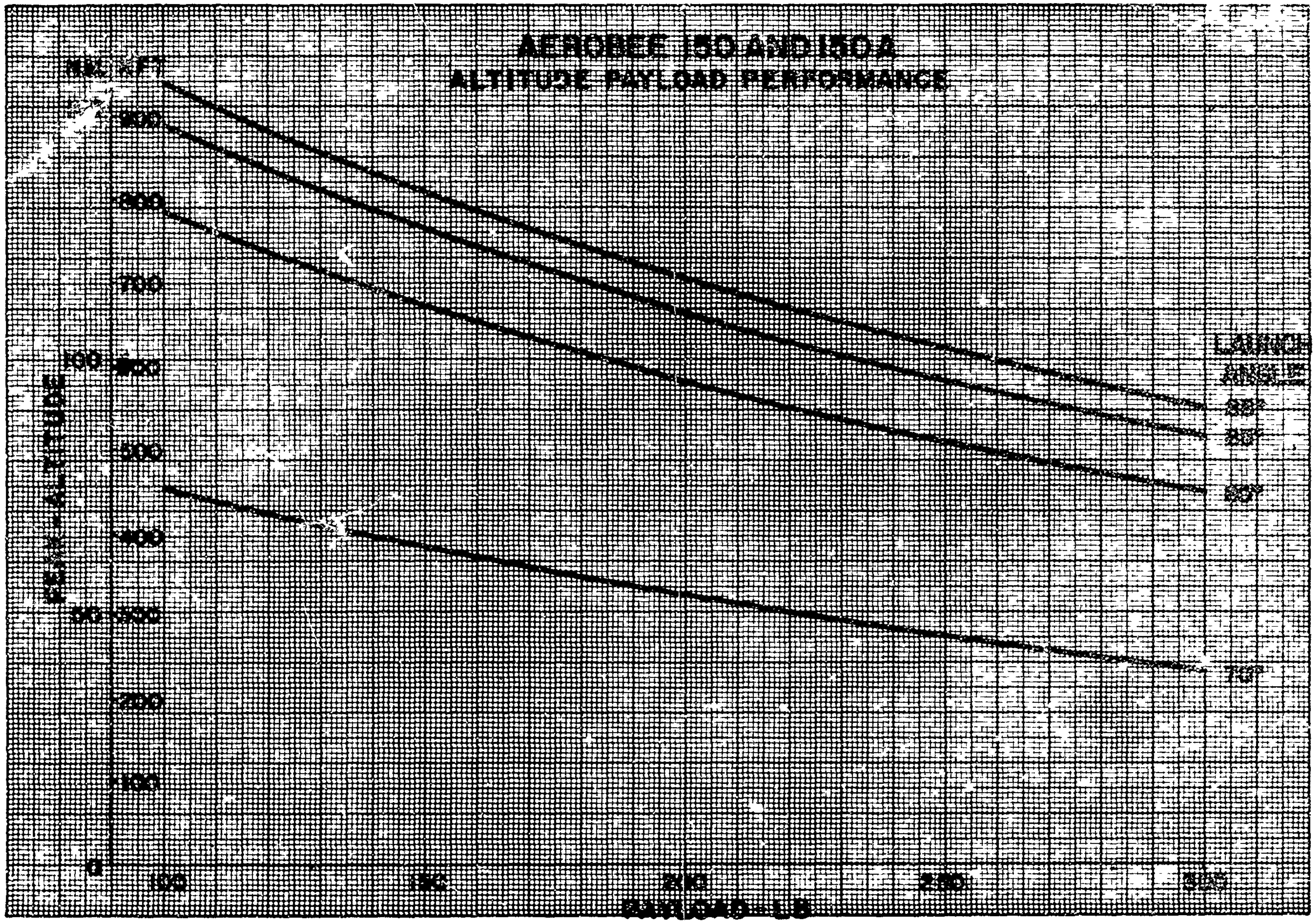
 Revised May 1964

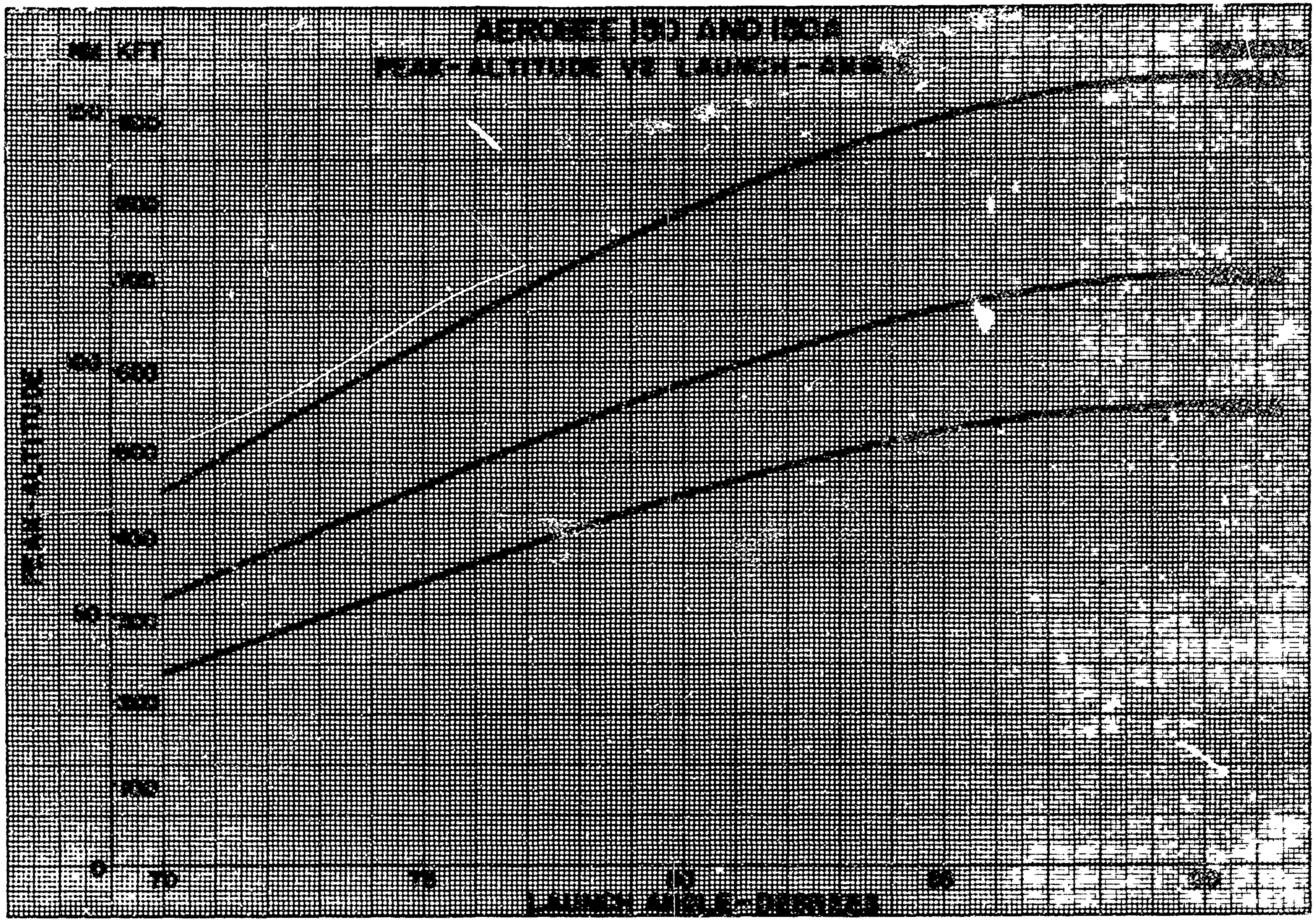
AEROBEE 150 AND 150 A

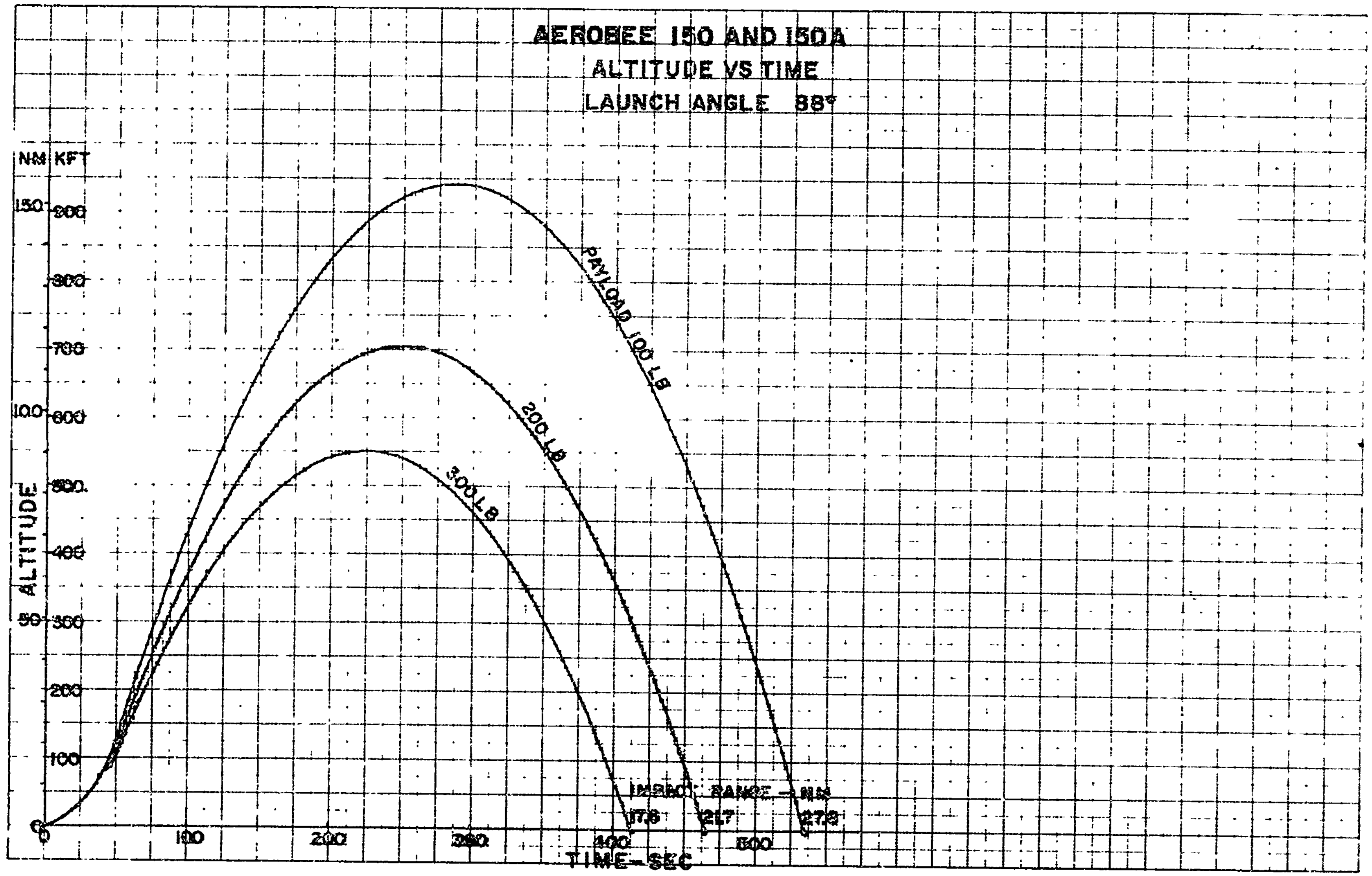


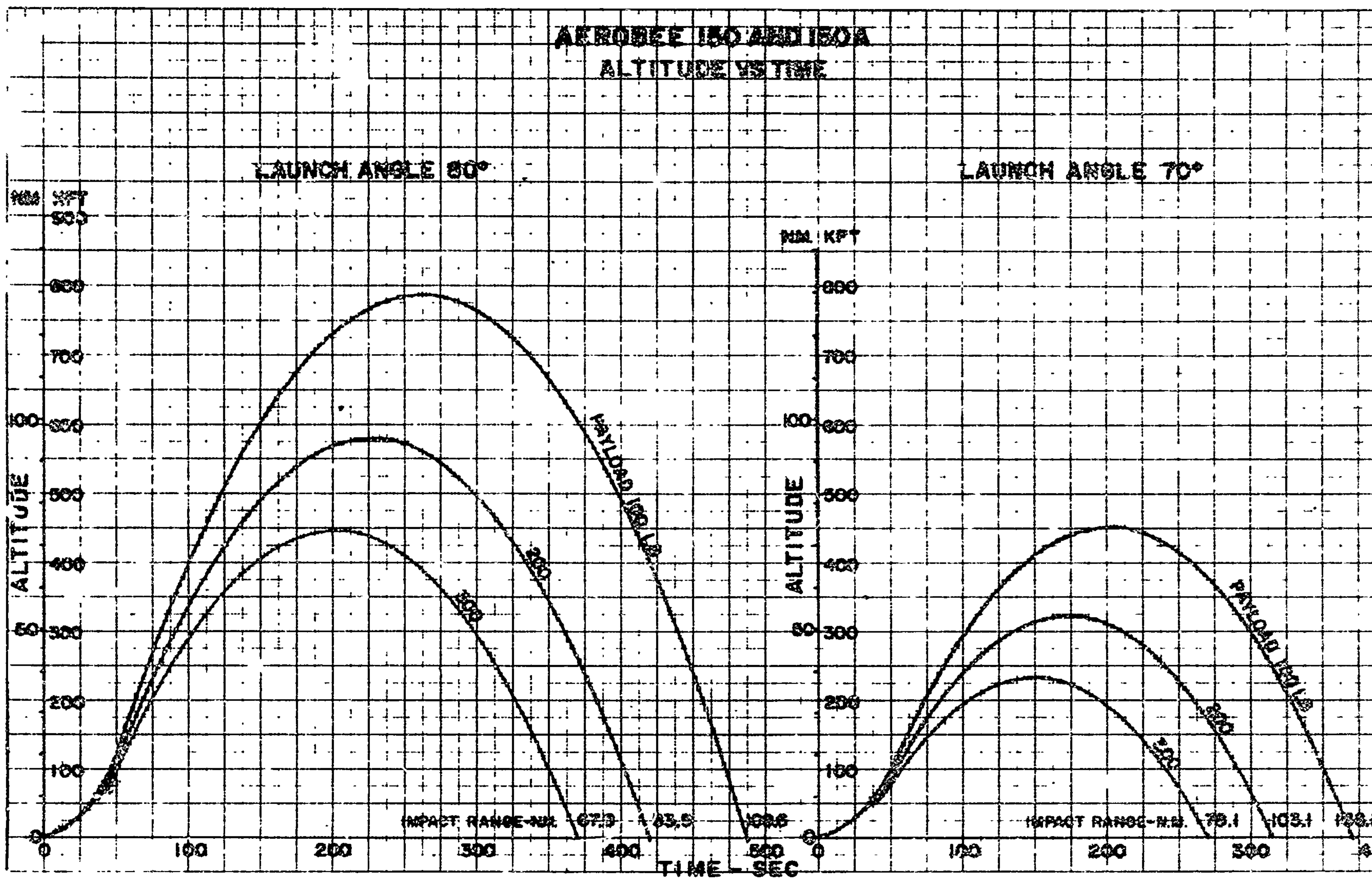
PAYLOAD VOLUME = 6.90 CU. FT. (INCLUDING EXTENSIONS)
4.75 CU. FT. (WITHOUT EXTENSIONS)

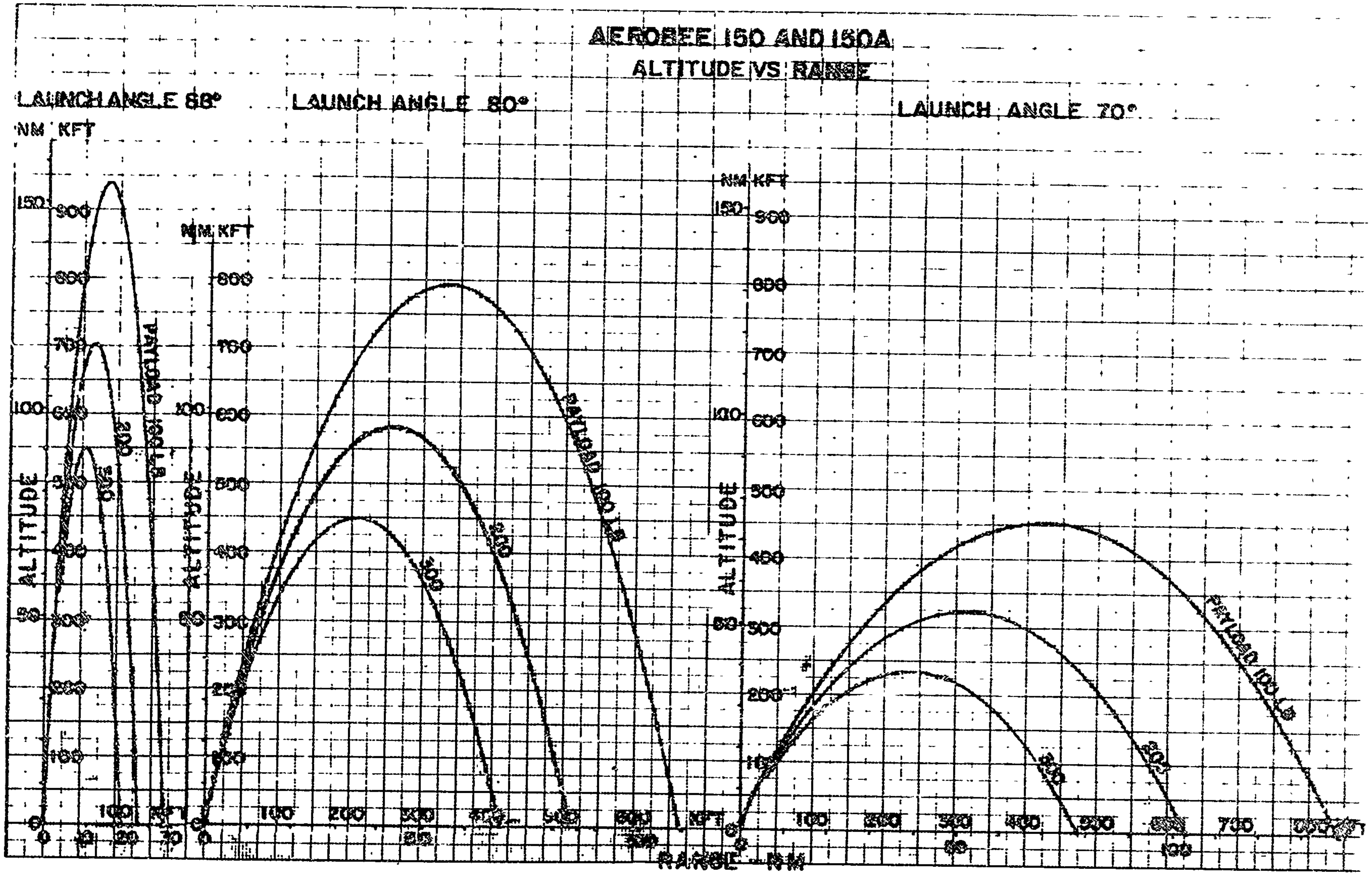
PAYLOAD COMPARTMENT

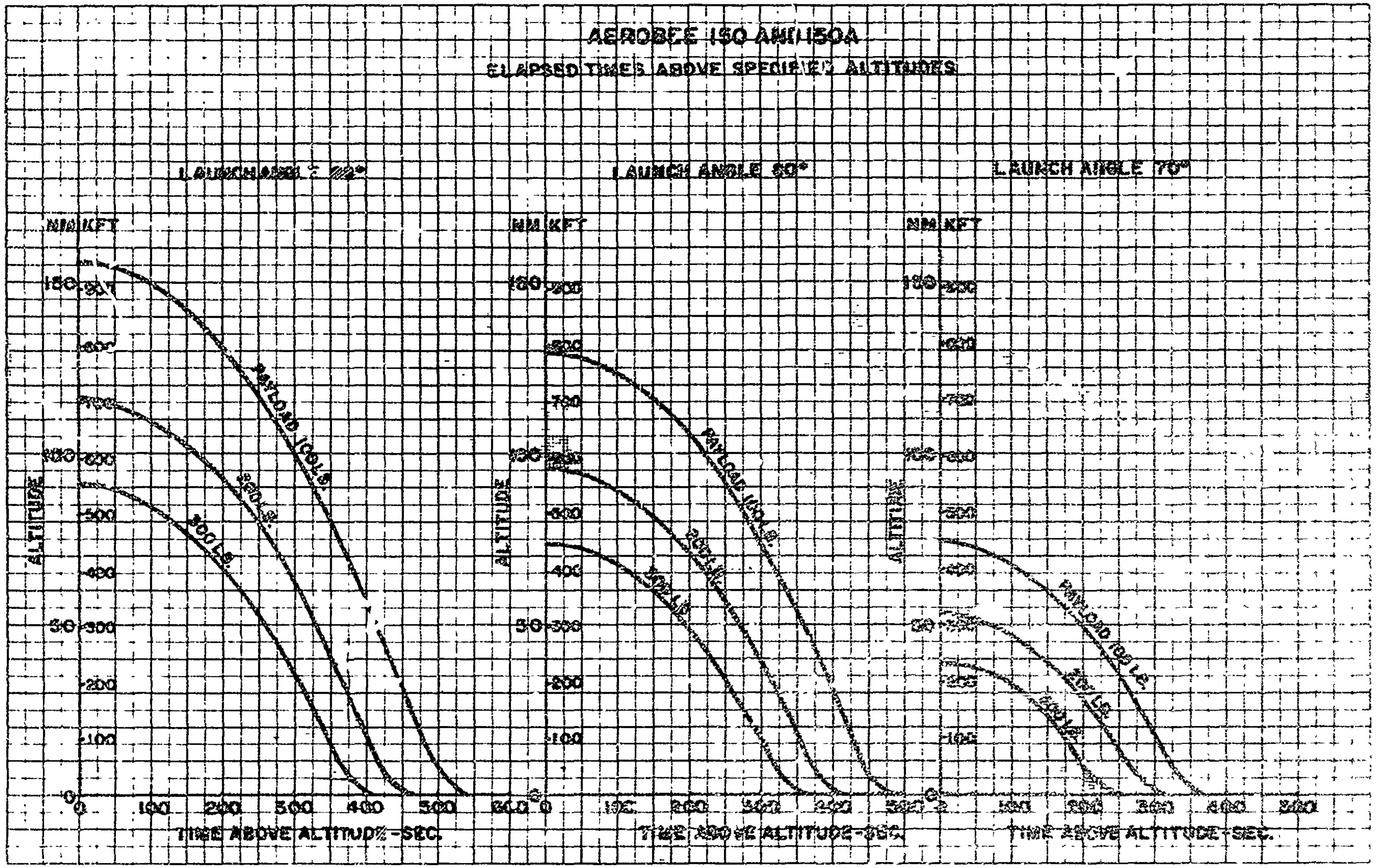

AEROBEE 150 AND 150A
ALTITUDE PAYLOAD PERFORMANCE
PEAK ALTITUDE
0
100
200
300
400
500
600
700
800
900
100
150
200
250
300
PAYLOAD - LB
LAUNCH
ANGLE

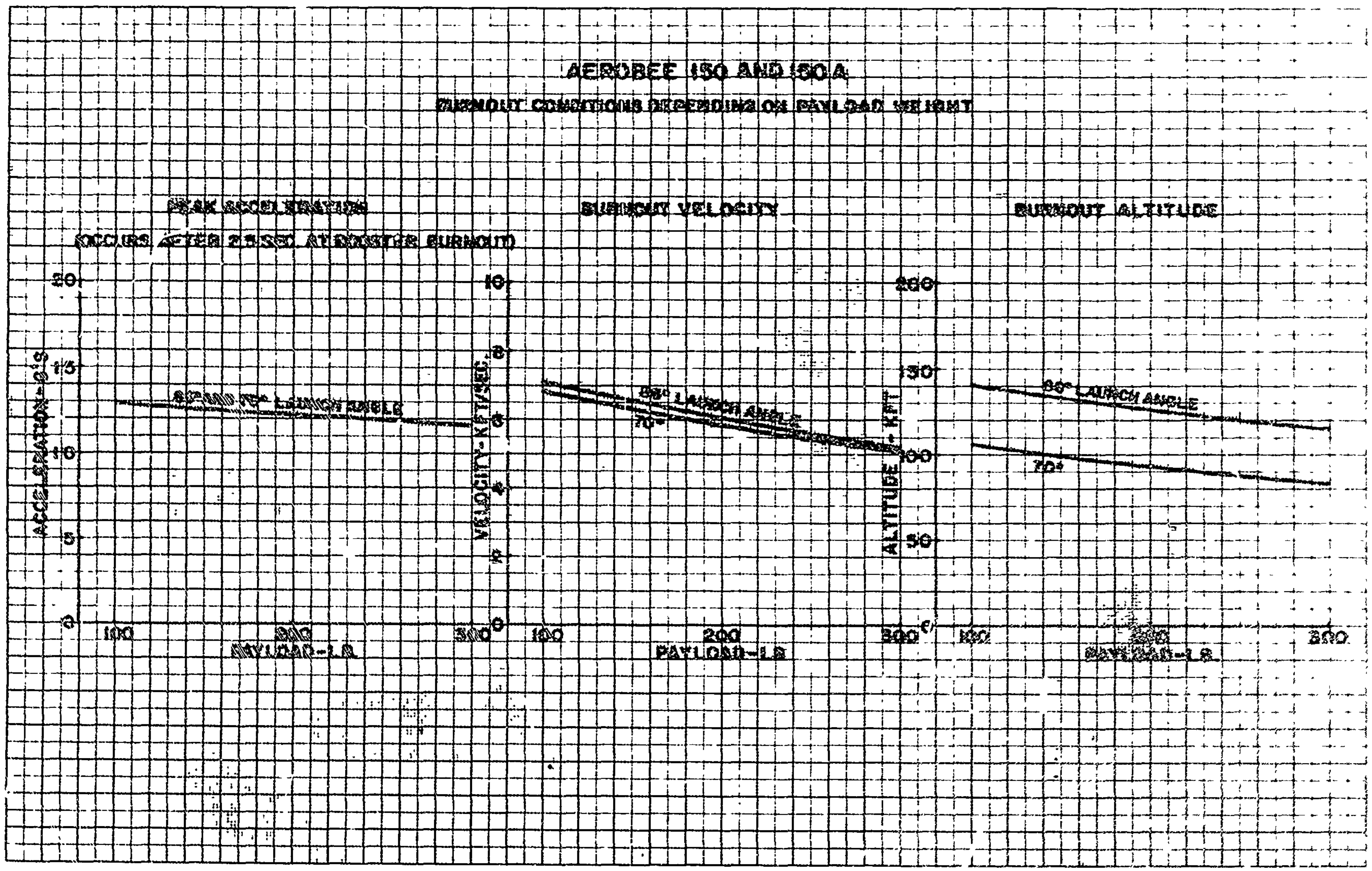

AEROBEE 150 AND 150A
PEAK-ALTITUDE VS LAUNCH-ANGLE
PEAK-ALTITUDE
KFT
LAUNCH ANGLE-DEGREES
0
70
75
80
85
90

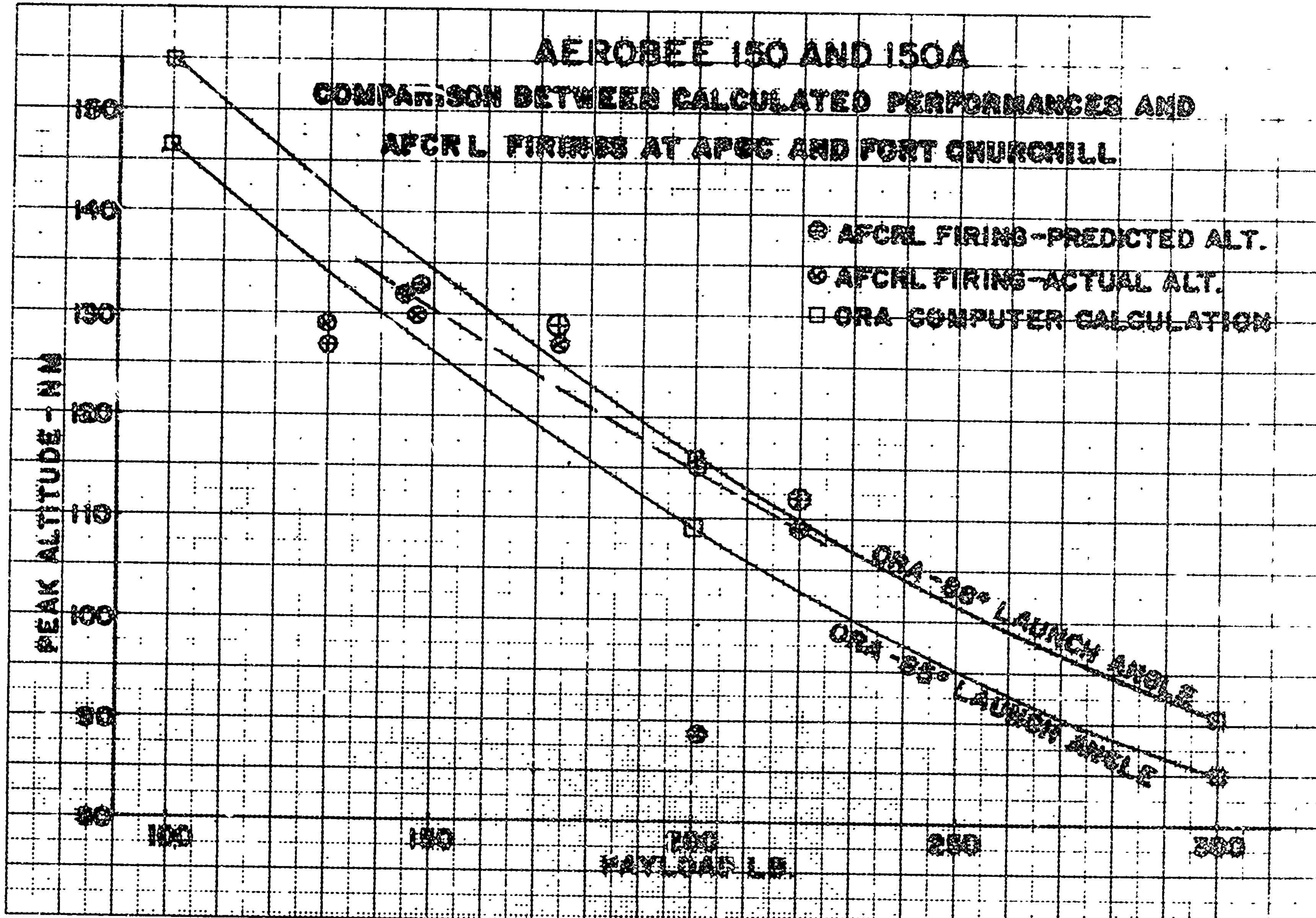

AEROBEE 150 AND 150A
ALTITUDE VS TIME
LAUNCH ANGLE 88°
NM KFT
150 900
800
700
100 600
500
ALTITUDE
400
50 300
200
100
0
0
100
200
300
400
500
TIME-SEC
PAYLOAD 100 LB
200 LB
300 LB
IMPACT RANGE - NM
17.6
21.7
27.8


AEROBEE 150 AND 150A
ALTITUDE VS TIME
LAUNCH ANGLE 80°
LAUNCH ANGLE 70°
ALTITUDE
N.M. KFT
ALTITUDE
N.M. KFT
PAYLOAD 150 LB
PAYLOAD 150 LB
IMPACT RANGE-N.M. 67.3 83.5
IMPACT RANGE-N.M. 79.1 103.1
TIME - SEC

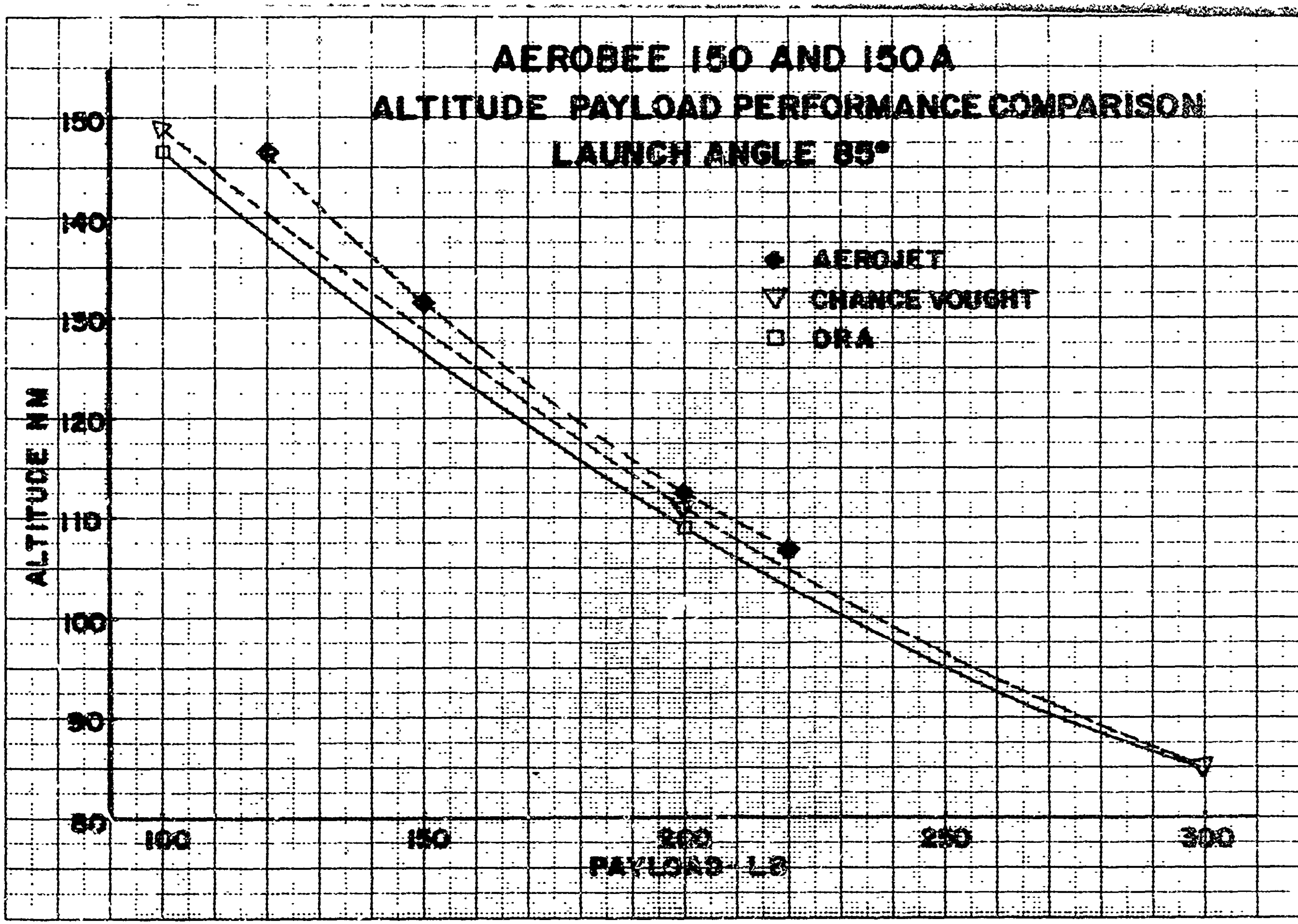

AEROBEE 150 AND 150A
ALTITUDE VS RANGE
LAUNCH ANGLE 88°
LAUNCH ANGLE 80°
LAUNCH ANGLE 70°
NM KFT
ALTITUDE
PAYLOAD 100 LB
200
300
RANGE - NM


AEROBEE 150 AND 150A
ELAPSED TIMES ABOVE SPECIFIED ALTITUDES
LAUNCH ANGLE 80°
LAUNCH ANGLE 70°
NM KFT
ALTITUDE
PAYLOAD 100 LB.
200 LB.
300 LB.
TIME ABOVE ALTITUDE-SEC.


AEROBEE 150 AND 150A
BURNOUT CONDITIONS DEPENDING ON PAYLOAD WEIGHT
PEAK ACCELERATION
(OCCURS AFTER 2.5 SEC. AT BOOSTER BURNOUT)
ACCELERATION - G'S
20
15
10
5
0
85° AND 70° LAUNCH ANGLE
100
200
300
PAYLOAD - LB
BURNOUT VELOCITY
VELOCITY - KFT/SEC.
10
8
6
4
2
0
85° LAUNCH ANGLE
70°
100
200
300
PAYLOAD - LB
BURNOUT ALTITUDE
ALTITUDE - KFT
200
150
100
50
0
85° LAUNCH ANGLE
70°
100
200
300
PAYLOAD - LB



AEROBEE 150 AND 150A
COMPARISON BETWEEN CALCULATED PERFORMANCES AND
AFCRL FIRINGS AT APGC AND FORT CHURCHILL
AFCRL FIRING-PREDICTED ALT.
AFCRL FIRING-ACTUAL ALT.
ORA COMPUTER CALCULATION
ORA-88° LAUNCH ANGLE
ORA-85° LAUNCH ANGLE
PEAK ALTITUDE - NM
150
140
130
120
110
100
90
80
PAYLOAD LB.
100
150
200
250
300


AEROBEE 150 AND 150 A
ALTITUDE PAYLOAD PERFORMANCE COMPARISON
LAUNCH ANGLE 85°
AEROJET
CHANCE VOUGHT
DRA
ALTITUDE NM
80
90
100
110
120
130
140
150
100
150
200
250
300
PAYLOAD LB

Ground Support Equipment

For the operation of the Aerobee 150 and 150A the following GSE is required:

(1) Launching Tower:

Launching towers for the 3 finned Aerobee 150 are available at WSMR; AFMDC, Holloman AFB (presently out of commission); APGC, Eglin AFB; and, Fort Churchill, Canada. The same launching tower can be used for the Aerobee 300.

The only launching tower for the 4 finned Aerobee 150A is the NASA Aerobee Tower at Wallops Island, Virginia, which may also be used for the Aerobee 300A.

The elevation angle of the Aerobee towers is restricted to a range of 80^{o} to 90^{o} above the horizon.

(2) Handling Trailer: for vehicle transport and erection into the tower a handling trailer is required. After erection the upper framework of the trailer becomes a part of the launching tower.

(3) Gas proof and Leak test panel for pressure checking of the Second Stage Vehicle.

(4) Helium pressurization console which provides pressure regulation checks for various operations of the vehicle.

(5) Electrical support equipment to check

a. The radio controlled fuel shut-off system and First Motion switch circuity.

b. The booster ignition squibs and fuel shut-off squibs.

Aerobee 150 and 150A

Aerodynamic Heating and Internal Heating of Payload Compartment

Aerodynamic heating above 80° Launch Angle is not critical and the heat input in the payload compartment is small due to the short duration of the flight.

For special trajectories below 80° Launch Angle, which would require a modification of the launcher, the heating becomes more critical with possible effects on the structure of nose cone and fins at Launch Angles in the vicinity of 70°.

The internal heating of the payload depends on factors like temperature at launch, heat output of payload, outside air temperatures during flight, aerodynamic heat input, sun radiation, heat insulation of payload compartment, absorptivity, emissivity and heat conduction properties of the skin material. It is therefore recommended to check the internal heating for every different payload and launch condition.

AEROBEE 300 AND 300A

AEROBEE 300 and 300A

VEHICLE DESCRIPTION

Name of Vehicle	Aerobee 300 and 300A
Designation	AJ60-09 Aerobee 300 AJ60-12 Aerobee 300A (Spaerobee)
Manufacturer	Space-General Corporation El Monte, California, a subsidiary of Aerojet-General-Corporation
Kind of Vehicle	3-stage fin stabilized probe vehicle
First Stage Motor	Aerojet 2.5 KS-18000
Second Stage Motor	Aerojet Aerobee 150 system
Third Stage Motor	Aerojet 1.8 KS-7800, Sparrow III
Payload-Altitude Capability for 88° Launch Angle	20 lb - 300 N. M. 60 lb - 220 N. M. 100 lb - 178 N. M.
Payload Volume	0.9 cu ft
Peak Acceleration	83 G's (20 lb payload, 88° L. A.)
Peak Deceleration	20 G's (20 lb payload, 88° L. A.)
Max. Velocity	10000 FPS (20 lb payload, 88° L. A.)
Launch Weight Less net-payload	2106 lb
Reliability	87%
Users	USAF, NASA
Sources	Aerojet, AFCRL, Chance Vought, NASA, Space-General Performance Computation: AFMDC Analog Computation Branch

AEROBEE 300 and 300A

The Aerobee 300 and 300A were developed from the Aerobee 150 series by adding the Navy's Sparrow III as a third stage. The Index "A" designates the four finned version of the normally three finned vehicle.

Basically, these vehicles are the same, however, the difference in the fins requires two different launching towers. The performance of the Aerobee 300A is slightly better, but as the difference is not significant the performances were calculated only for the Aerobee 300A version.

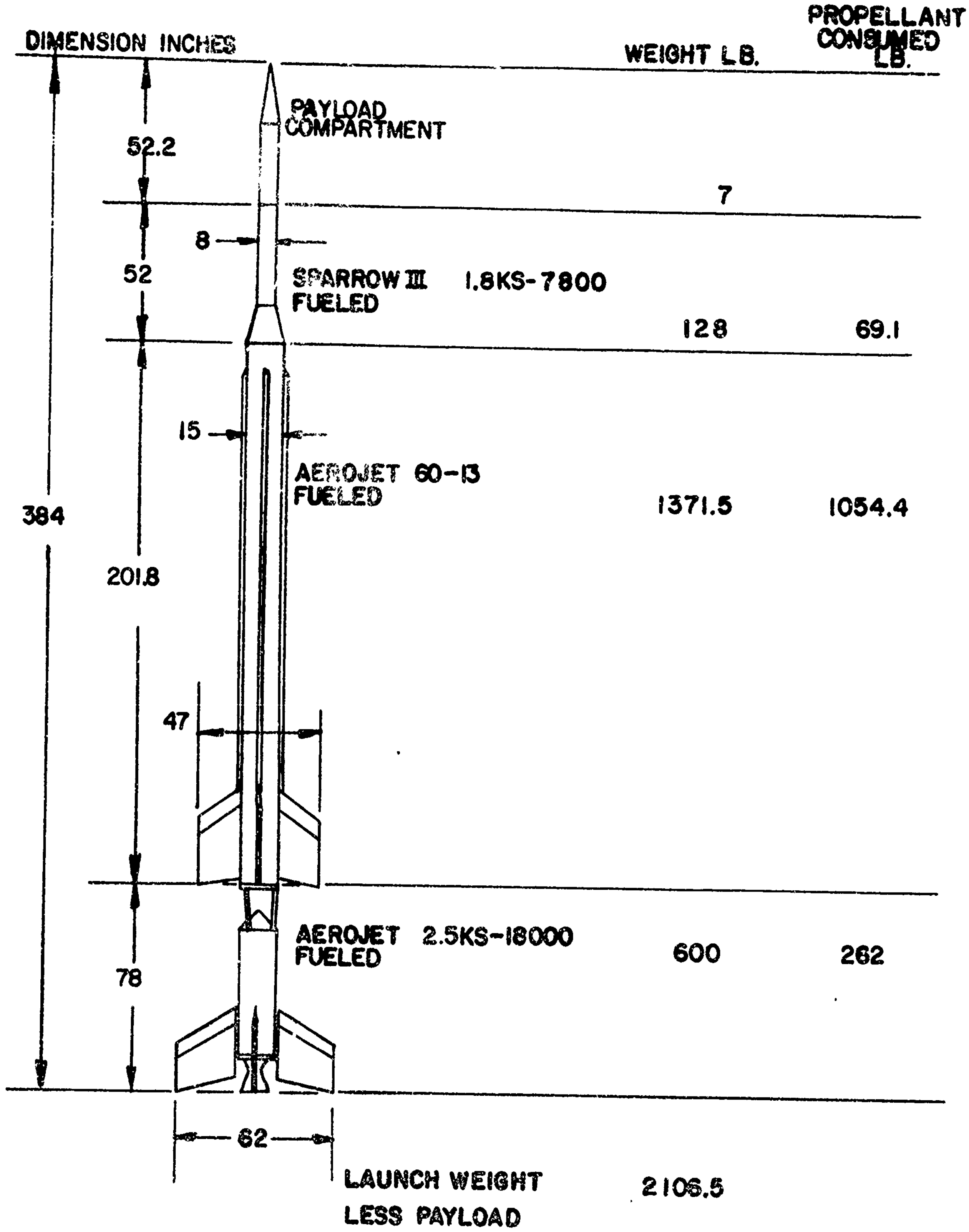
The booster and second stage fins are the same as used on the Aerobee 150 and 150A vehicles. Booster fins are adjusted to an angle of attack of $2^\circ\ 30'$ to impart a roll rate as the vehicle leaves the tower. The second stage fins are adjustable within a range from $0^\circ\ 0'$ to $0^\circ\ 2'$ angle of attack for an additional desired roll rate.

The firing sequence for the first two stages is the same as for the Aerobee 150 series. The booster burns for a total of 2.5 seconds. After 0.3 seconds of booster burning time the second stage is ignited and burns for a total of 52 seconds. Accordingly the booster and the second stage burning times overlap for 2.2 seconds. Separation of the booster from the second stage occurs at booster burnout. Third stage ignition and separation is initiated upon detection of the pressure drop in the second stage motor at burnout. The third stage motor burns for 1.8 seconds. There are no coasting periods between the stage operations.

Approximately 22 vehicles were launched by the end of 1962.

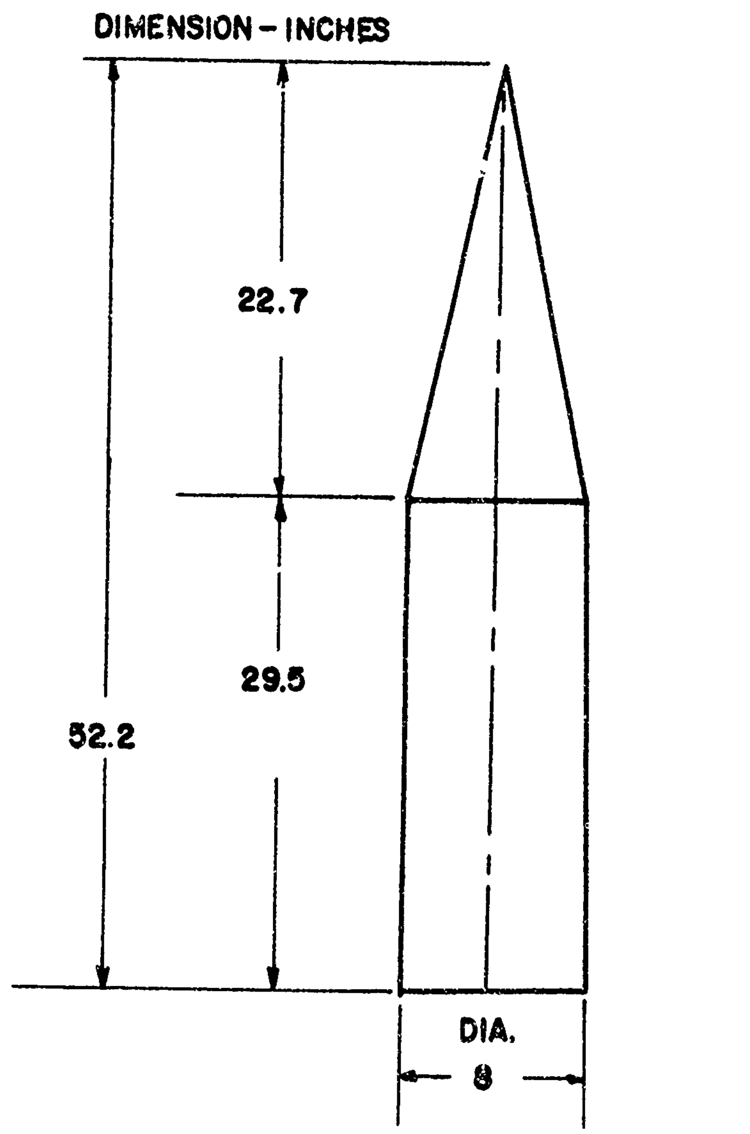
AEROBEE 300 AND 300A
ASSEMBLY, DIMENSIONS AND WEIGHTS

PAYLOAD 20-100LB.

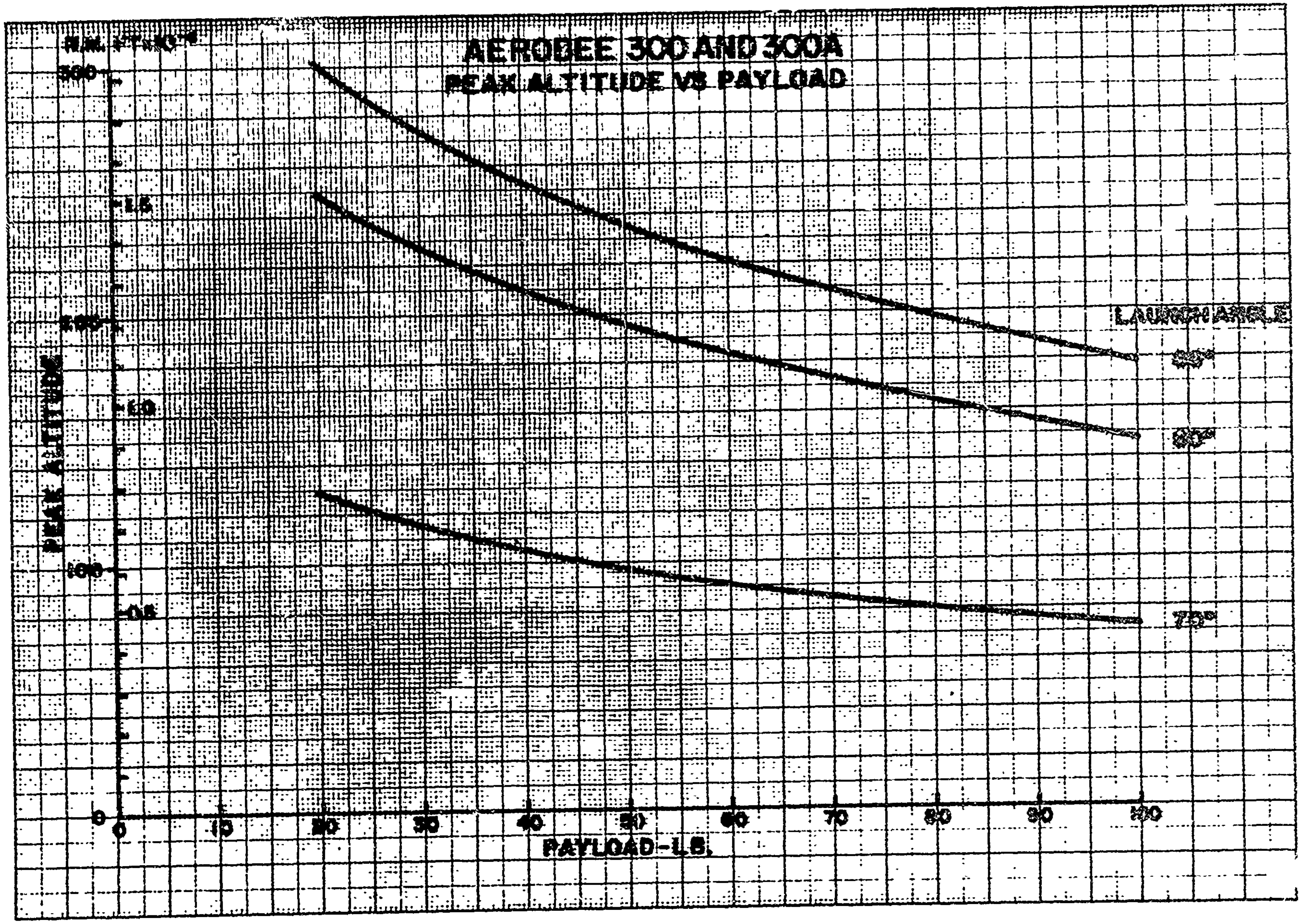


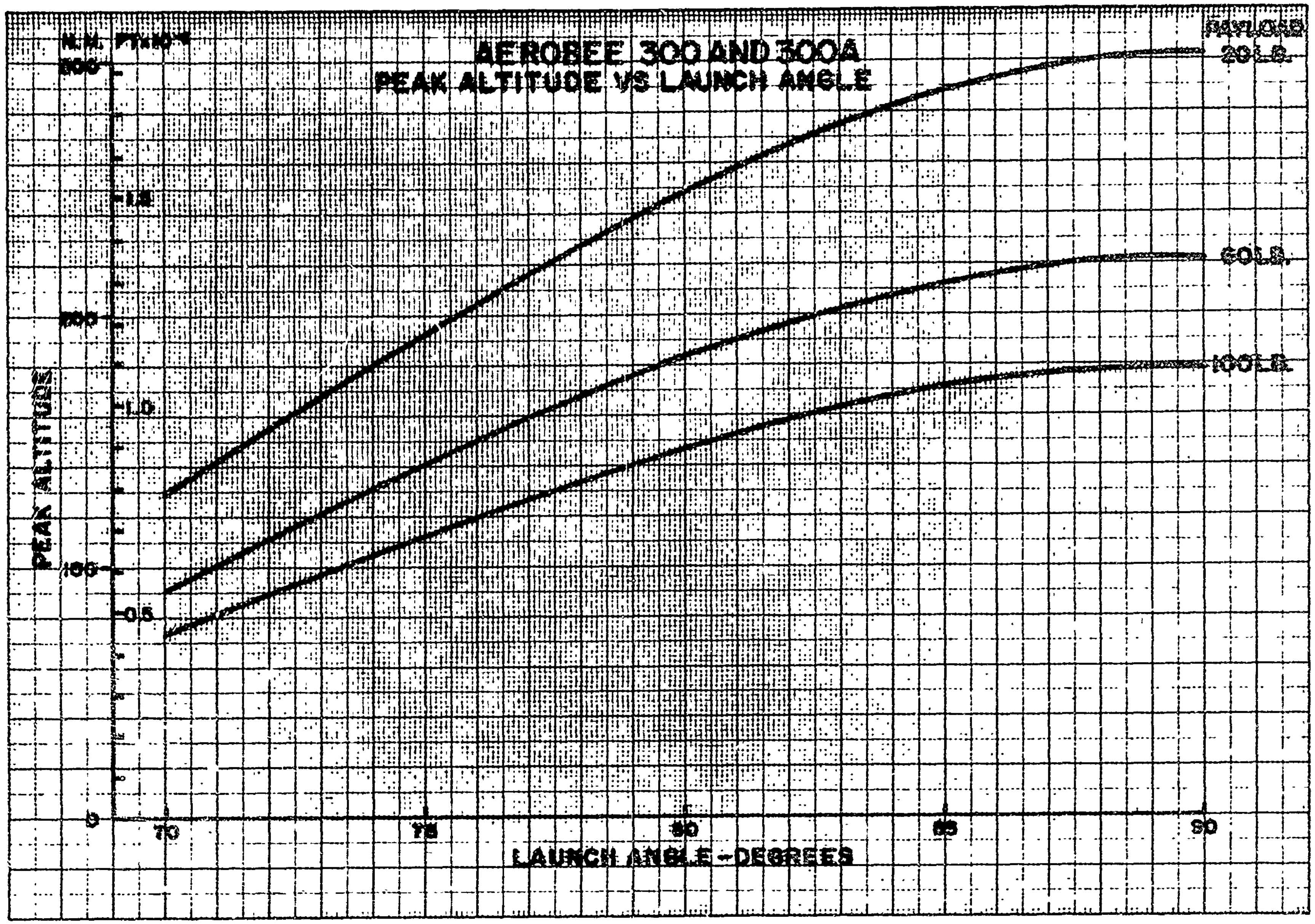
AEROBEE 300 AND 300A

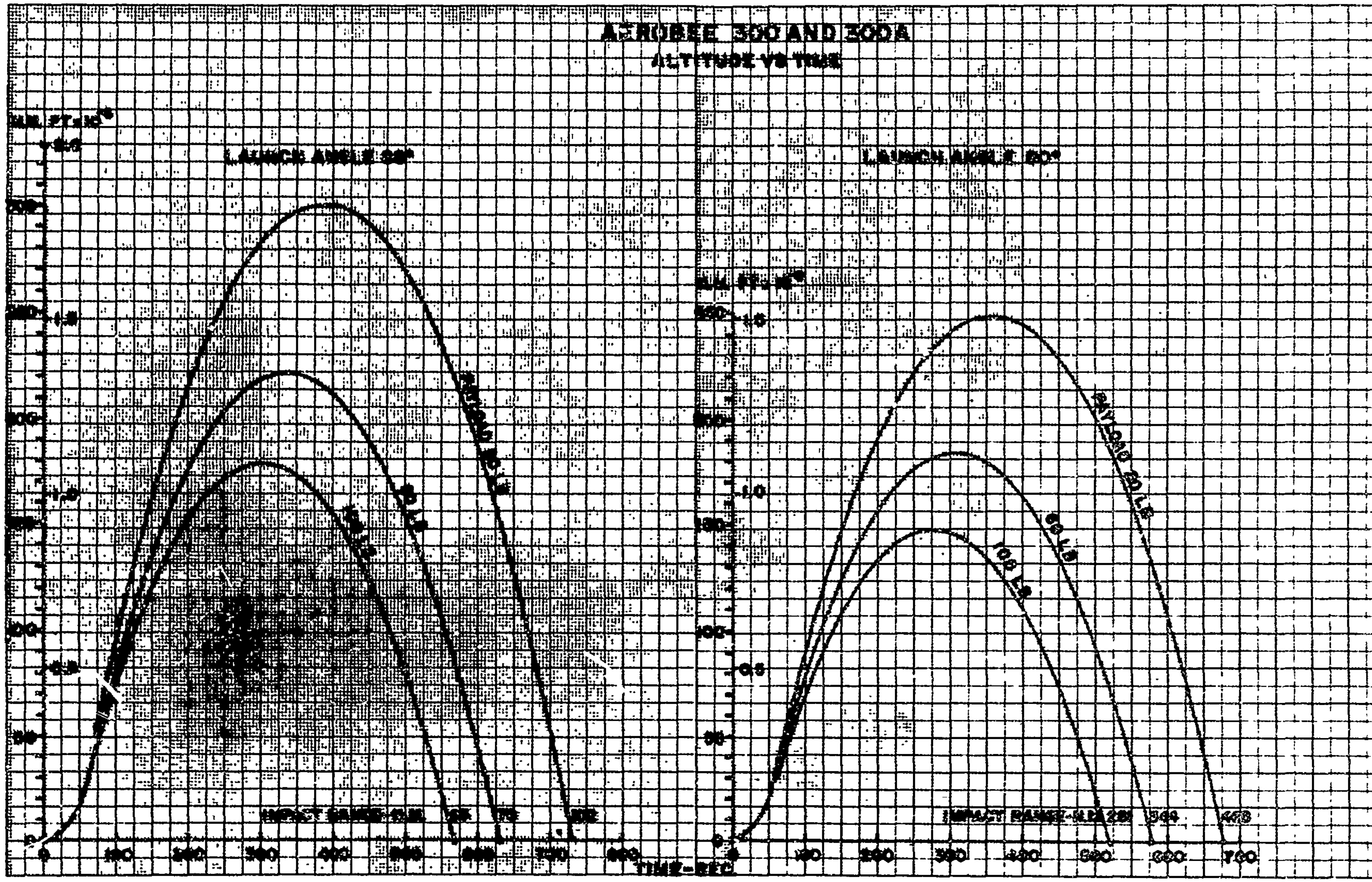
PAYLOAD COMPARTMENT

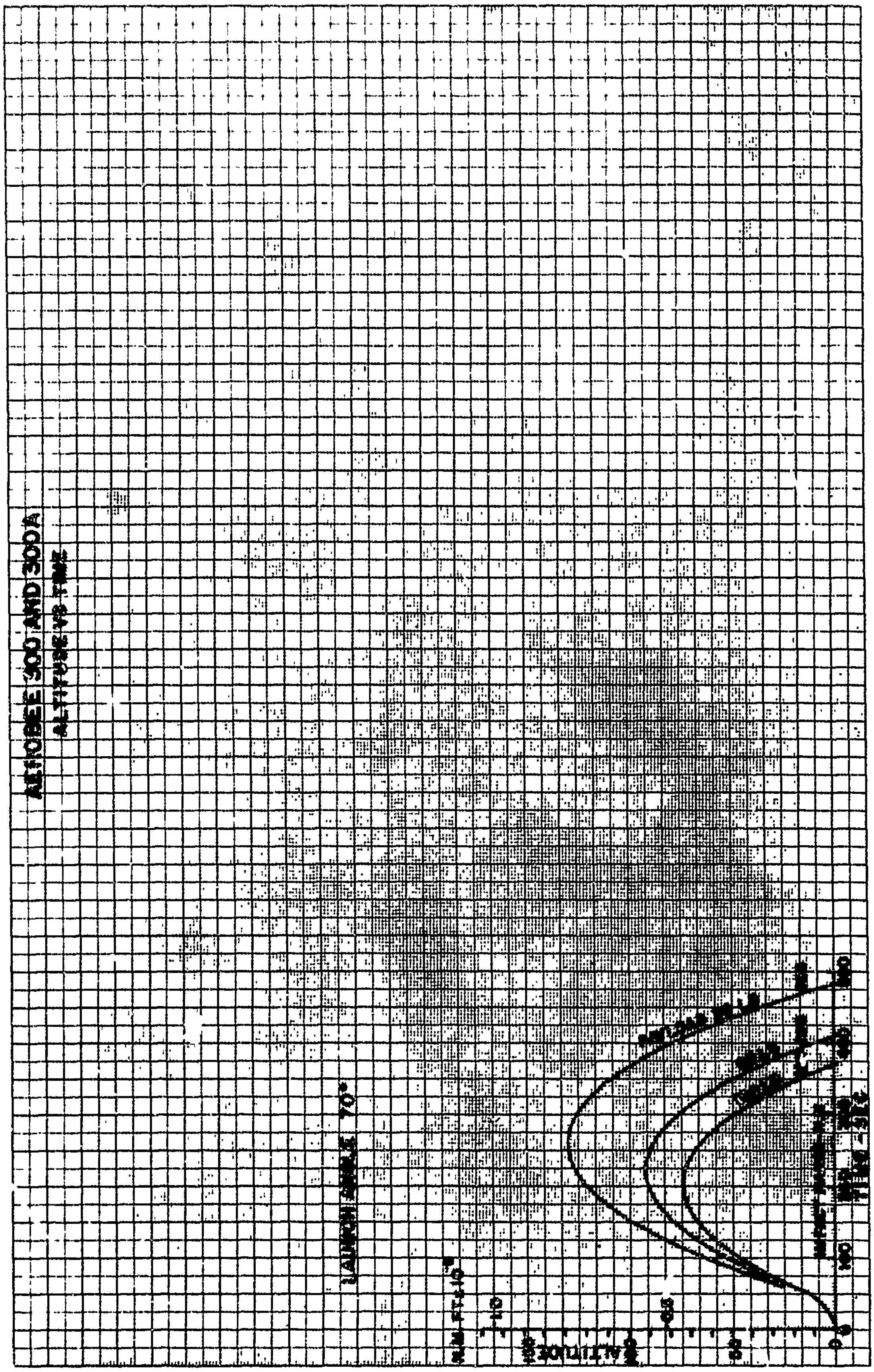


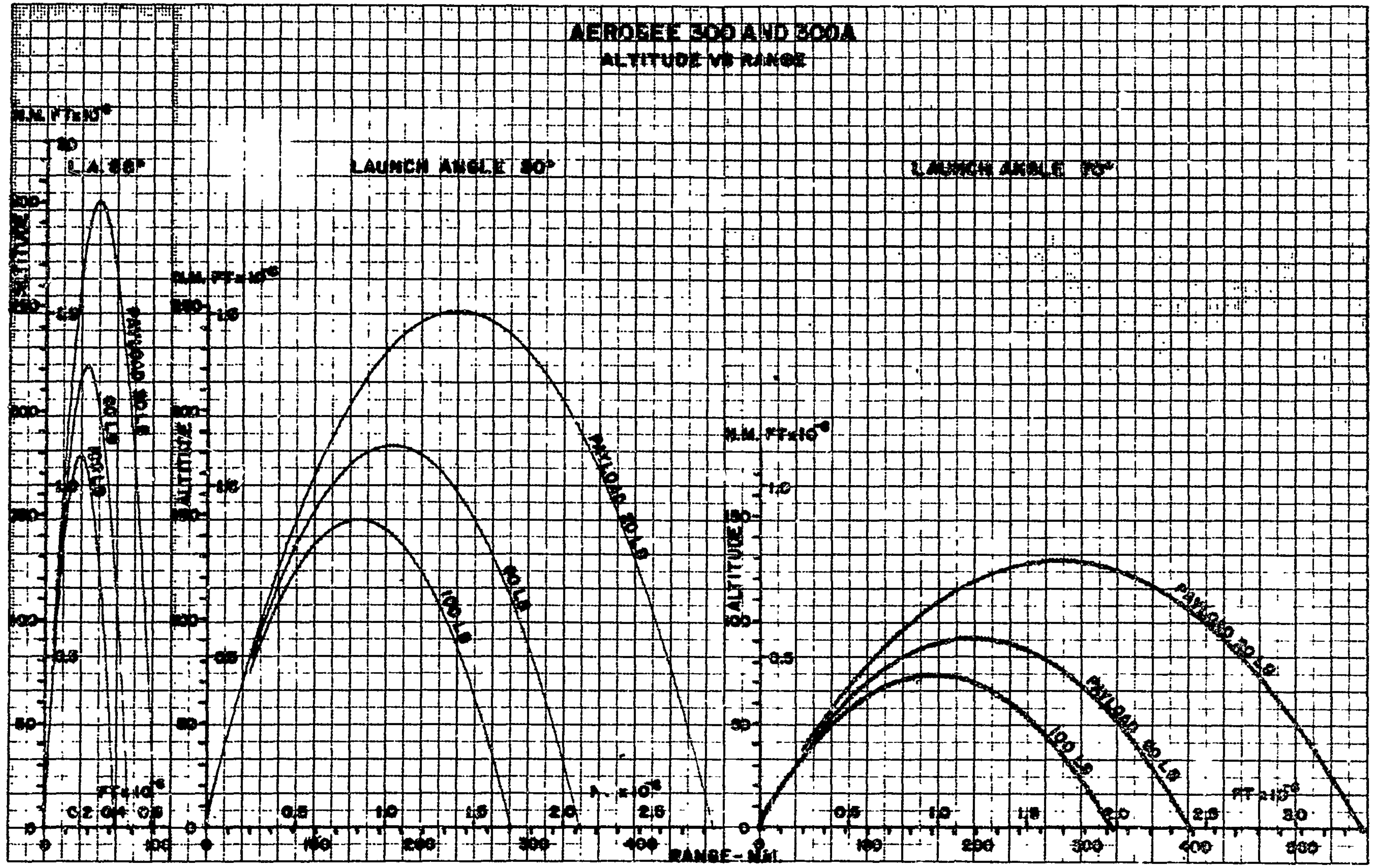
PAYLOAD VOLUME 0.9 CU.FT.

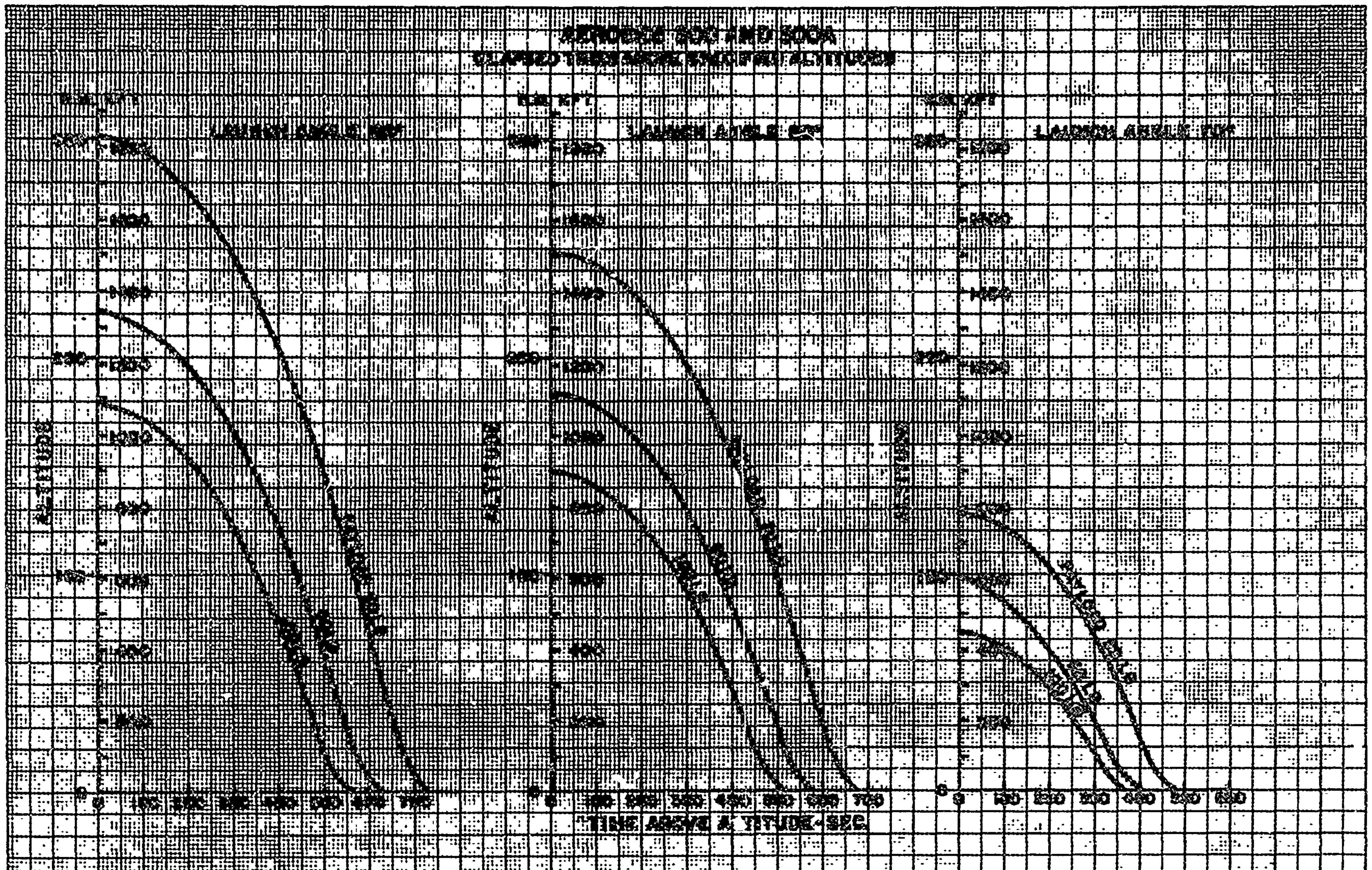

AEROBEE 300 AND 300A
PEAK ALTITUDE VS PAYLOAD
PEAK ALTITUDE
300
200
100
1.5
1.0
0.5
LAUNCH ANGLE
80°
75°
0
10
20
30
40
50
60
70
80
90
100
PAYLOAD-LB.

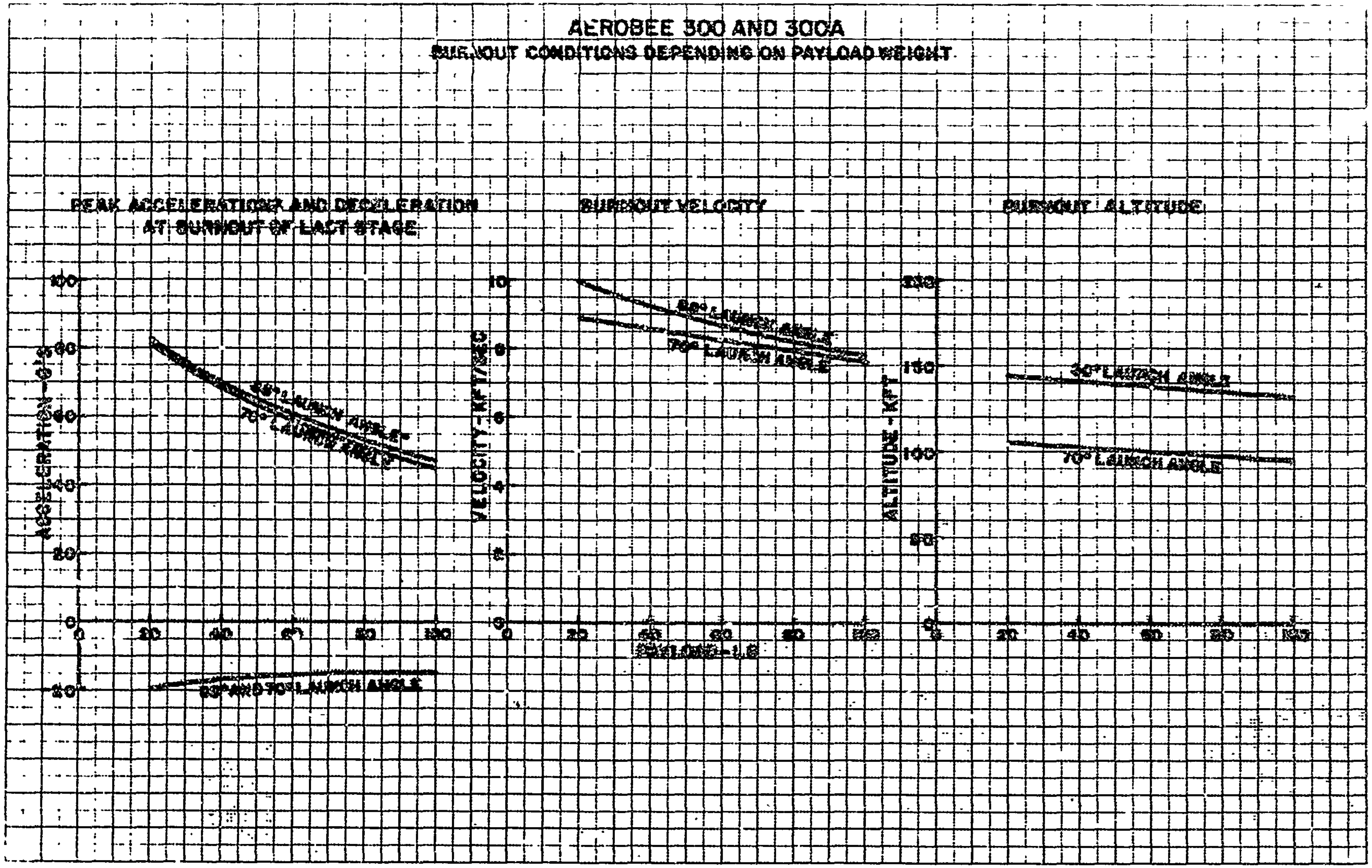

AEROBEE 300 AND 300A
PEAK ALTITUDE VS LAUNCH ANGLE
N.M.
FT×10⁻⁶
PEAK ALTITUDE
0
100
200
300
0.5
1.0
1.5
70
75
80
85
90
LAUNCH ANGLE - DEGREES
PAYLOAD
20 LB.
60 LB.
100 LB.


AEROBEE 300 AND 300A
ALTITUDE VS TIME
LAUNCH ANGLE 80°
PAYLOAD 20 LB
100 LB
TIME–SEC

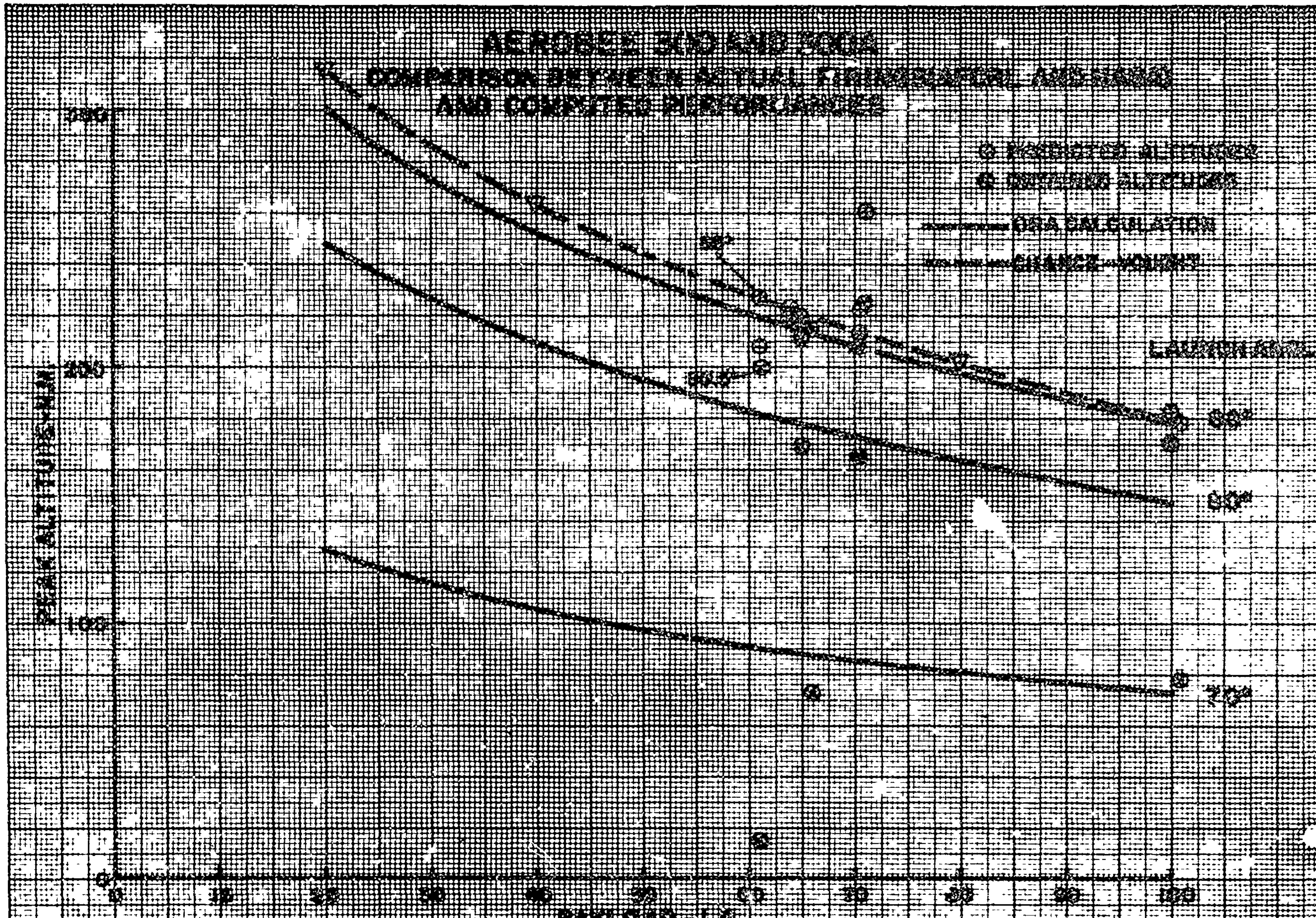

AEROBEE 300 AND 300A
ALTITUDE VS TIME
LAUNCH ANGLE 70°
ALTITUDE
N.M. FT.×10⁶
TIME - SEC


AEROBEE 300 AND 300A
ALTITUDE VS RANGE
L.A. 85°
LAUNCH ANGLE 80°
LAUNCH ANGLE 70°
N.M.
FT×10⁶
ALTITUDE
PAYLOAD 50 LB
80 LB
100 LB
PAYLOAD 80 LB
RANGE - N.M.


AEROBEE 300 AND 300A
ELAPSED TIME ABOVE SPECIFIED ALTITUDES
ALTITUDE
TIME ABOVE ALTITUDE-SEC



AEROBEE 300 AND 300A
BURNOUT CONDITIONS DEPENDING ON PAYLOAD WEIGHT


AEROBEE 300 AND 300A
AND COMPUTED PERFORMANCES
CHANCE-VOUGHT
LAUNCH ANGLE
PEAK ALTITUDE-N.M.
PAYLOAD - LB.
70°
80°
86°

GROUND SUPPORT EQUIPMENT

For the operation of the Aerobee 300 and 300A the following equipment is required:

(1) Launching Tower

Launching towers for the finned Aerobee 300 are available at Eglin AFB, Florida; White Sands Missile Range, New Mexico; Holloman AFB, New Mexico (presently out of commission); and, Fort Churchill, Canada. These launching towers are also used for the Aerobee 150.

The only launching tower for the 4 finned Aerobee 300A is the NASA Aerobee tower at Wallops Island, Virginia, which may also be used for the Aerobee 150A .

(2) Handling Trailer

The handling trailer is used for vehicle transport and erection into the tower, where the upper framework of the trailer becomes a part of the launching tower.

(3) Handling Dolly

The handling dolly provides a roll-over fixture for the vehicle and is also used as a holding fixture while adding components.

(4) Gas Proof and Leak Test Panel for pressure checking of the second stage tankage.

(5) Helium Pressurization Console which provides pressure regulation checks for various operations of the vehicle.

(6) Electrical Support Equipment for the checking of

a. The radio controlled fuel shut-off system and first motion switch circuity, and

b. the booster ignition squibs, fuel shut-off squibs of the second stage and the ignition squibs of the third stage.

AEROBEE 300 and 300A

AERODYNAMIC HEATING AND HEATING OF PAYLOAD COMPARTMENT

Aerodynamic heating at launch angles above 80° is not critical. The aerodynamic heat input into the payload compartment is small due to the short duration of the flight. At 85° launch angle the manufacturer claims a maximum temperature of the payload of 200° F.

At launch angles between 75° and 70° the aerodynamic heating becomes critical for the nose tip and the leading edges of the fins.

It should be noted that the internal heating of the payload is influenced by many factors like temperature at launch, heat output of the payload, outside air temperature during flight, aerodynamic heat input, heat input by sun radiation and earth albedo, heat insulation of the compartment, absorptivity, emissivity, and heat conduction - properties of the skin material, etc. Therefore the internal heating of the payload should be checked for every different payload and launch condition.

NIKE-CAJUN

NIKE-CAJUN

VEHICLE DESCRIPTION

Name of Vehicle	Nike-Cajun
Designations	Nike-Cajun, Argo B-1
Manufacturers	University of Michigan, Ann Arbor. Aero Lab Development Company, Pasadena, California. Atlantic Research Corporation, Duarte, California.
Kind of Vehicle	2 stage fin stabilized probe vehicle
First Stage Motor	Nike M5, 2.5 DS-59000 (X216-A2) Radford Arsenal
Second Stage Motor	Cajun, 3.08 KS-8190 (TE-82-1) Thiokol Chemical Corporation
Payload - Altitude Capability for 80° Launch Angle	25 lb - 107 N. M. 50 lb - 90 N. M. 100 lb - 70 N. M.
Payload - Volume	0.521 cu ft - 0.775 cu ft
Peak Acceleration Peak Deceleration	77 G 8 G (25 lb payload, 70° - 88° L. A.)
Max. Velocity	6900 FPS (25 lb payload, 70° L. A.)
Launch Weight less net payload	1518.9 lb
Reliability	83%
Users	US Air Force, Army, Navy, NASA
Sources	Aerolab, Atlantic Research, NASA, Ling-Temco-Vought, AFCRL, APGC, NRL. Performance Computation: AFMDC Analog Computation Branch.

NIKE-CAJUN

Developed from the Nike-Deacon, the Nike-Cajun is the most used probe vehicle next to the Arcas Sounding Rocket. Designed in 1956 by the Engineering Research Institute at the University of Michigan, the number of launchings was well above 200 by the end of 1962. The reasons for its extended use are low costs connected with a good reliability record and simplicity of handling and launching. It has been launched from a variety of launching sites: WSMR, APGC, Wallops Island, Fort Churchill, Guam, Mariana Islands, and from on board the USS Rushmore in the North Atlantic.

Despite careful assumptions with respect to air drag, the ORA calculated altitude-payload performances appear too good, when compared with measurements taken during actual flights (see page 3-15). The reason might be that the vehicle describes undulating motions inducing more drag than anticipated. A new set of fins under development at AFCRL for use on Cajun and Apache second stages might improve stability and performance.

For planning purposes, use of estimated 75° launch-angle curves on the ORA charts should produce realistic performances.

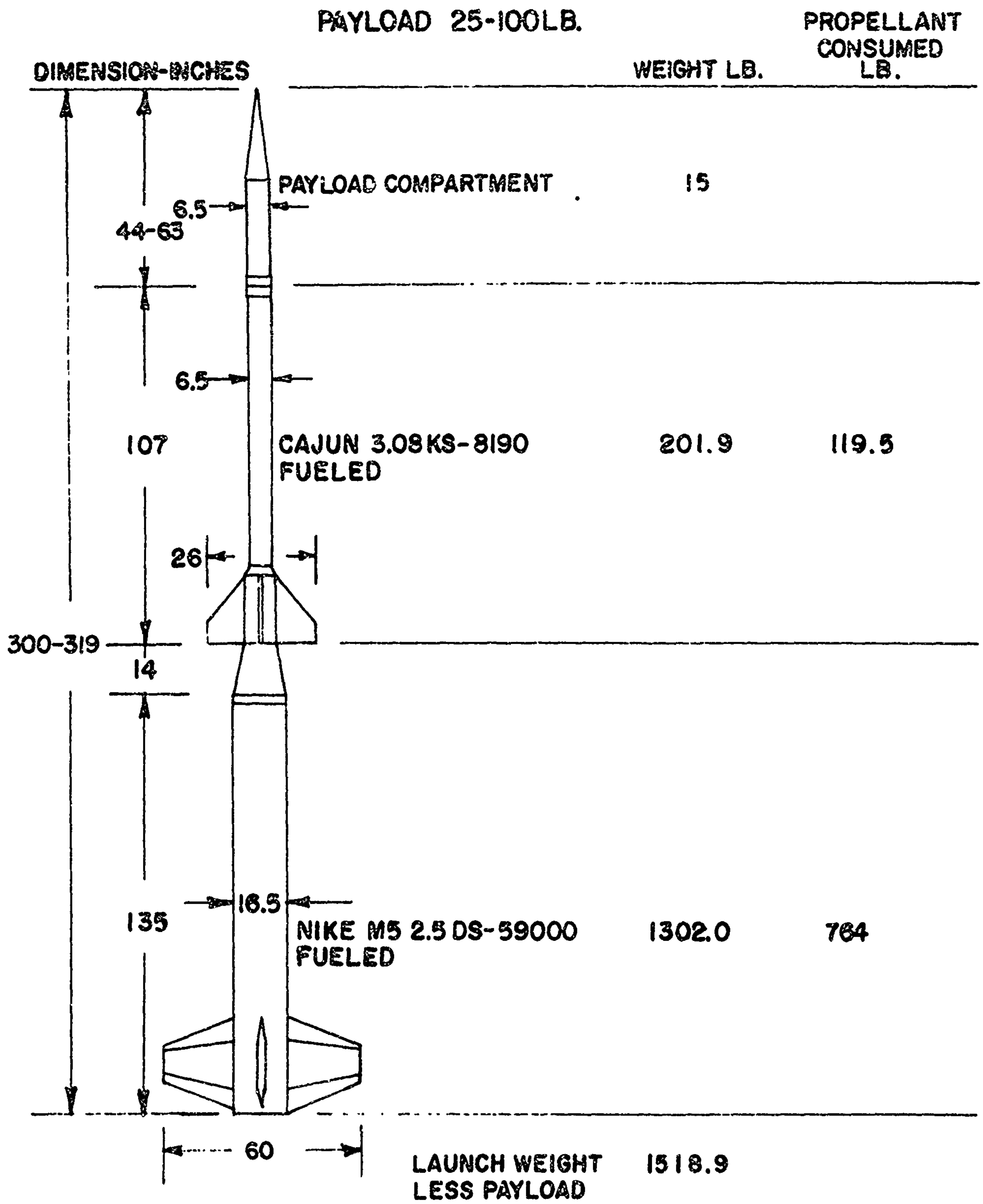
The firing sequence is as follows: the first stage Nike motor burns for 3.5 seconds. Separation of first and second stage is induced by differential drag pulling a slip-fit coupling connected to the Nike booster out of the Cajun nozzle throat. To reach maximum altitude, the second stage has to coast for a time period between 13 seconds and 21 seconds before ignition, to avoid severe air drag in low altitude. The graph on page 3-14 shows a flat maximum in peak altitude for this coasting period. The second stage Cajun motor is fired by a pyrotechnic delay squib ignited at launch. This stage has a burning time of 2.9 seconds.

Normally the Nike-Cajun is adjusted for a no-spin condition. This means that only a very small roll rate is tolerated.

If spin stabilization is desired variable incidence fins for the Nike-Booster and interchangeable spin tabs for the Cajun-fins are offered by the manufacturers.

NIKE-CAJUN

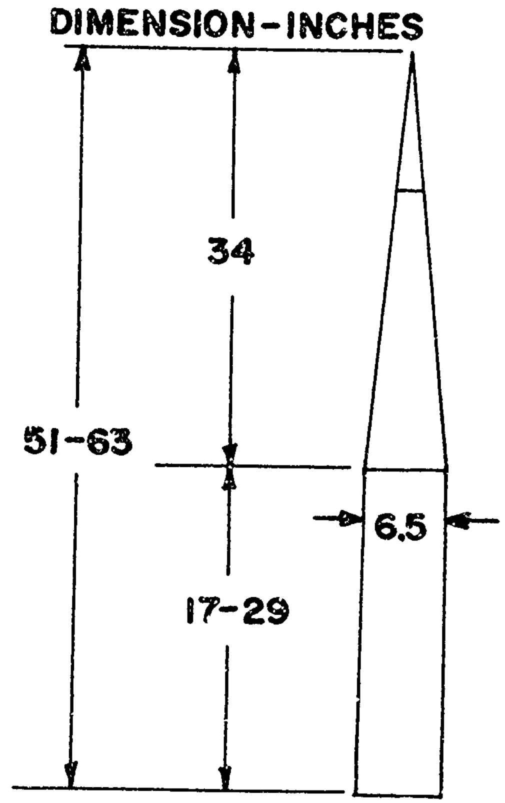
ASSEMBLY, DIMENSIONS AND WEIGHTS



38

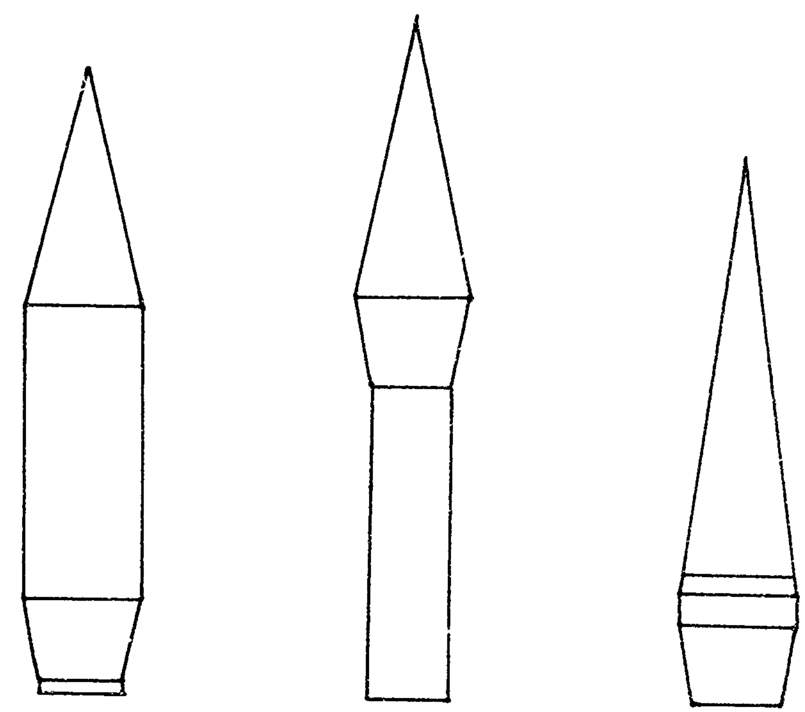
NIKE-CAJUN

PAYLOAD COMPARTMENTS

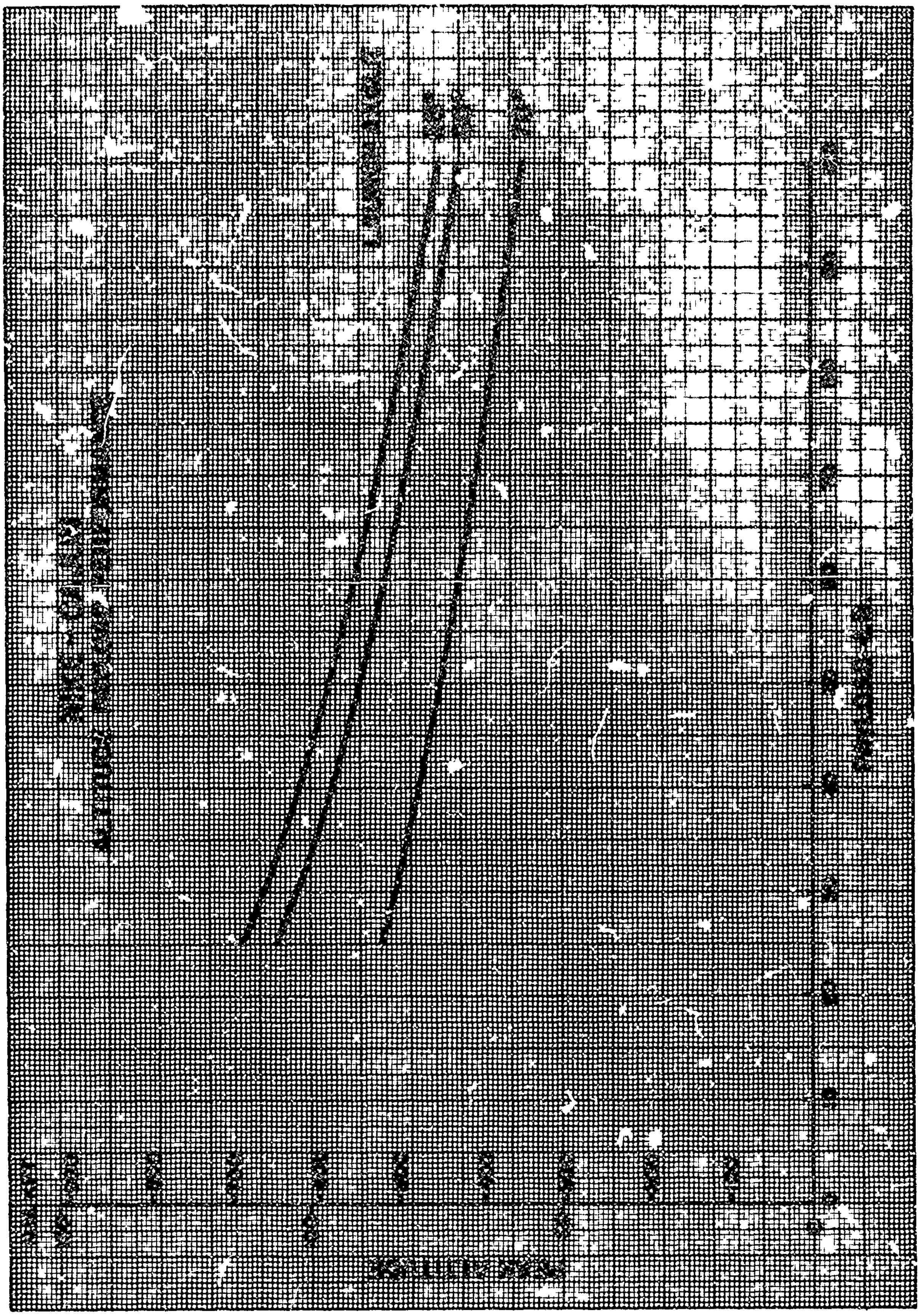


PAYLOAD VOLUME FROM 0.521-0.775 CU.FT.

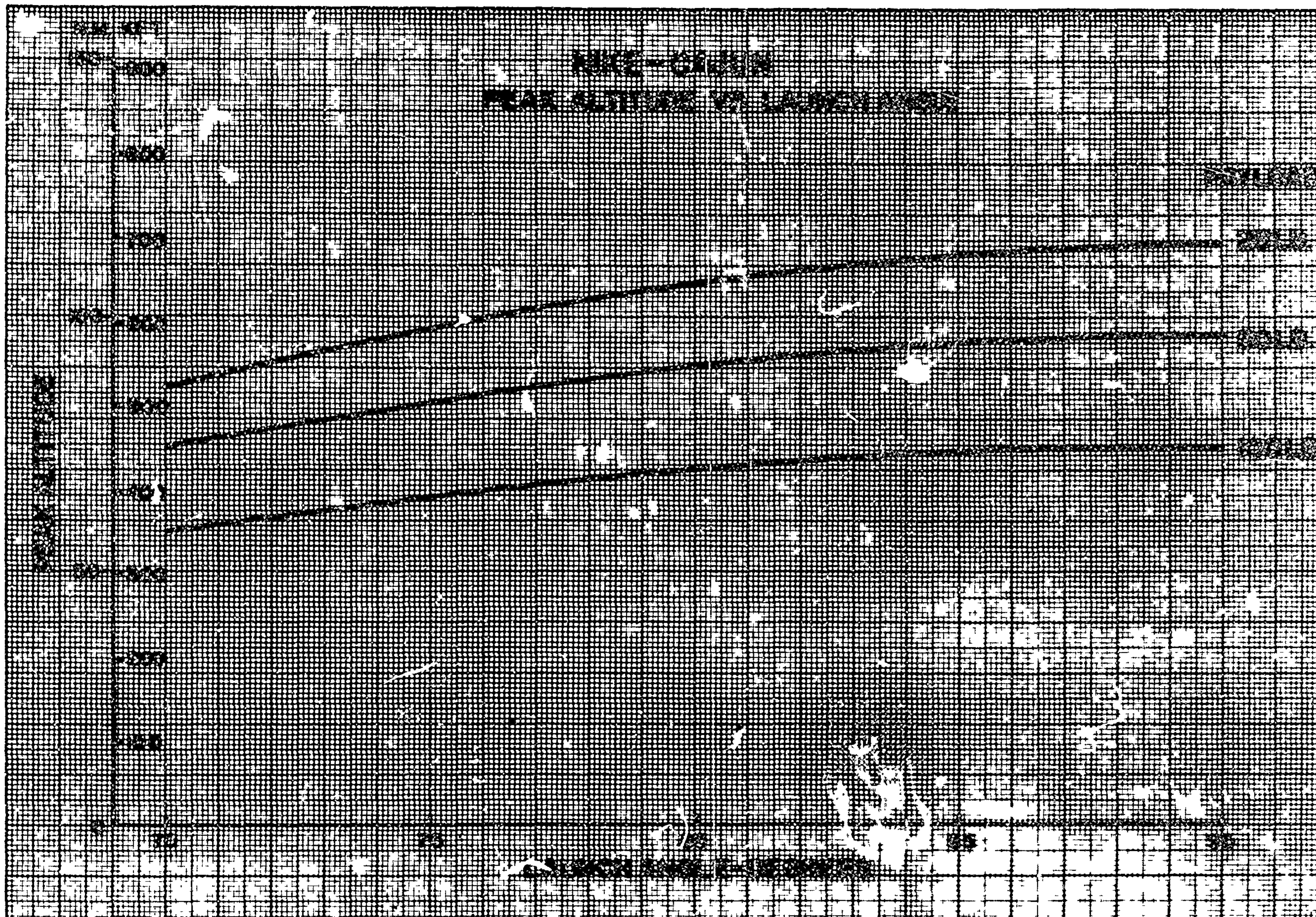
STANDARD SHAPE PAYLOAD COMPARTMENT

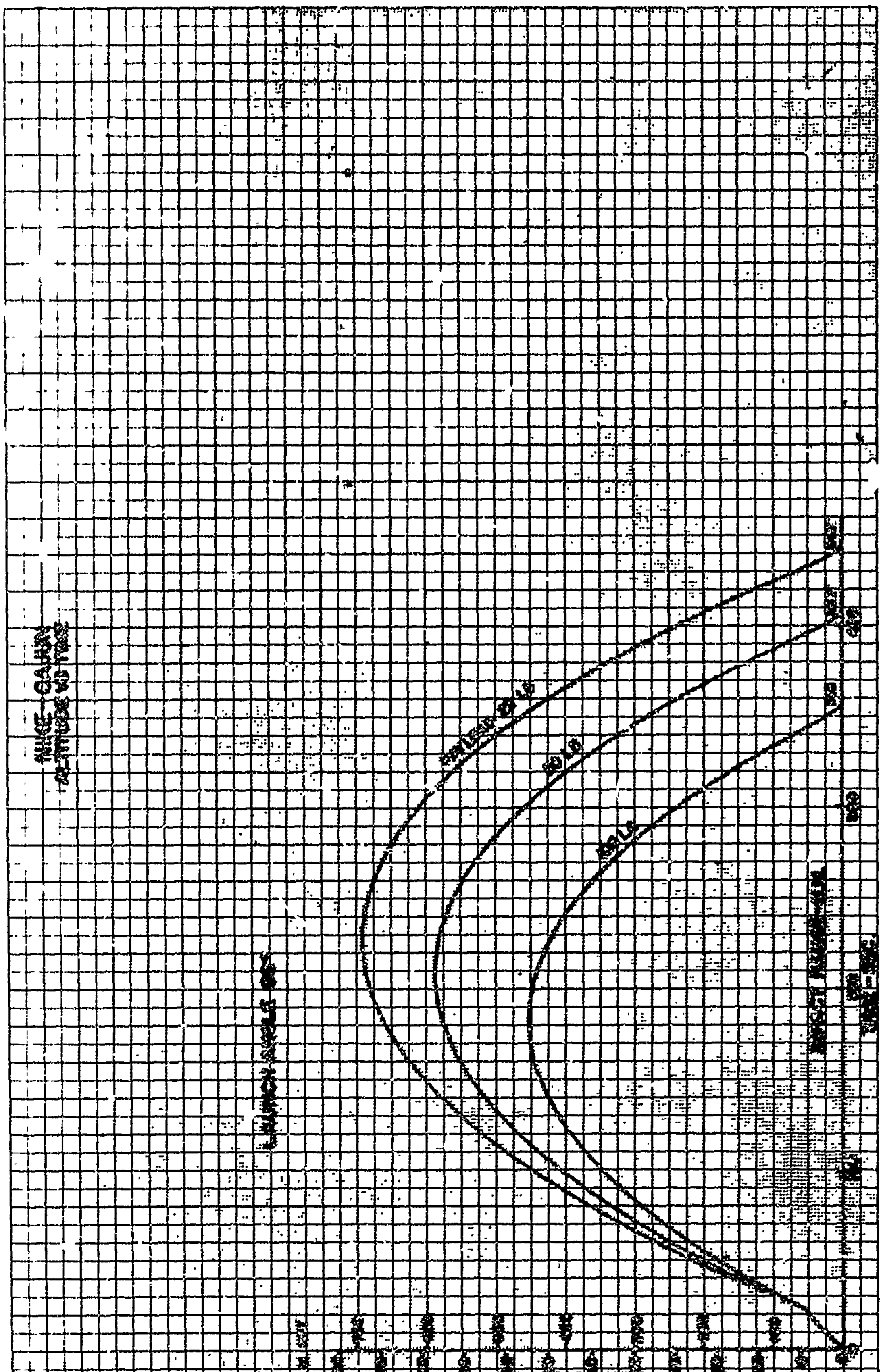


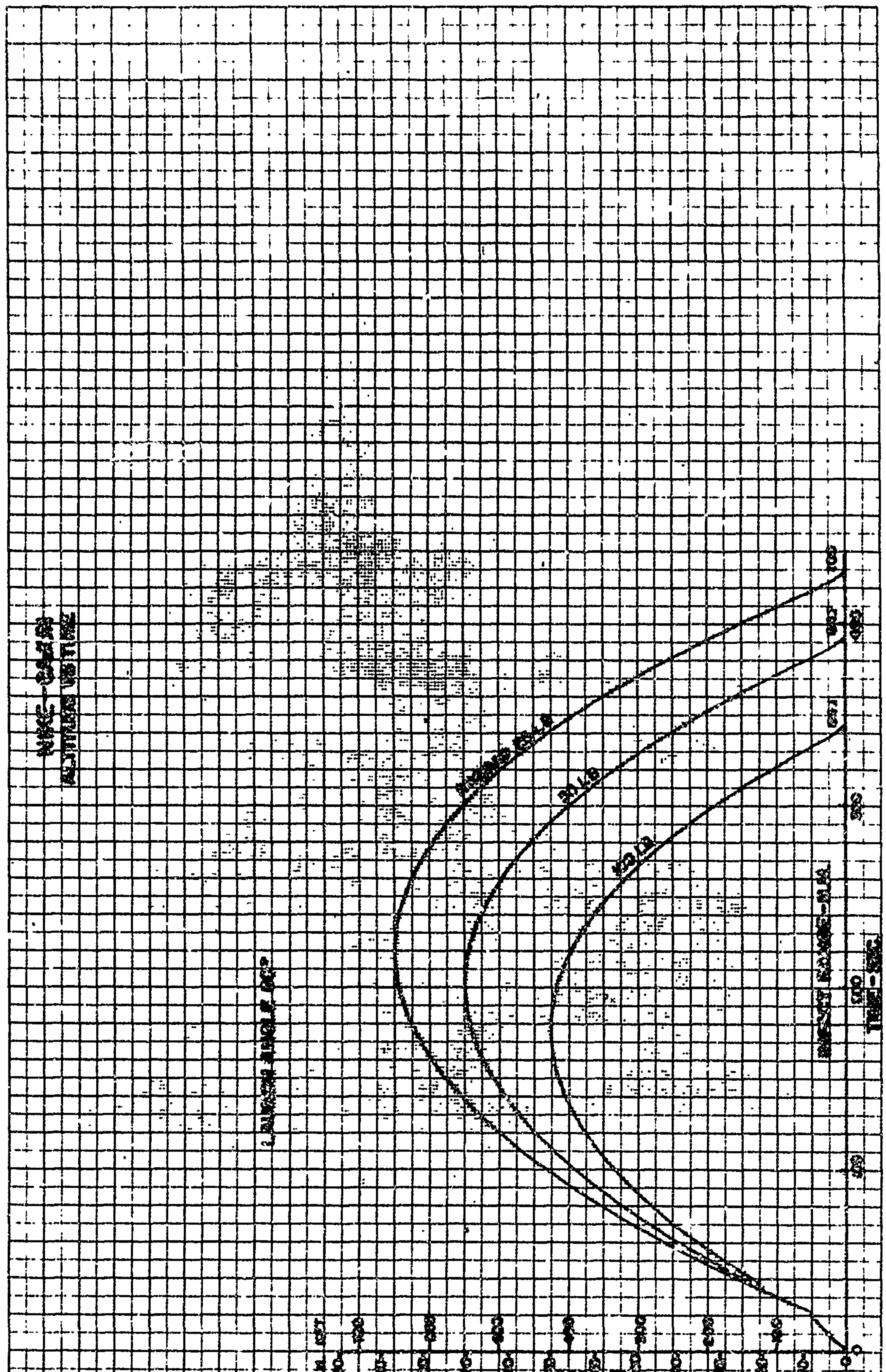
OTHER CONFIGURATIONS OFFERED



1340

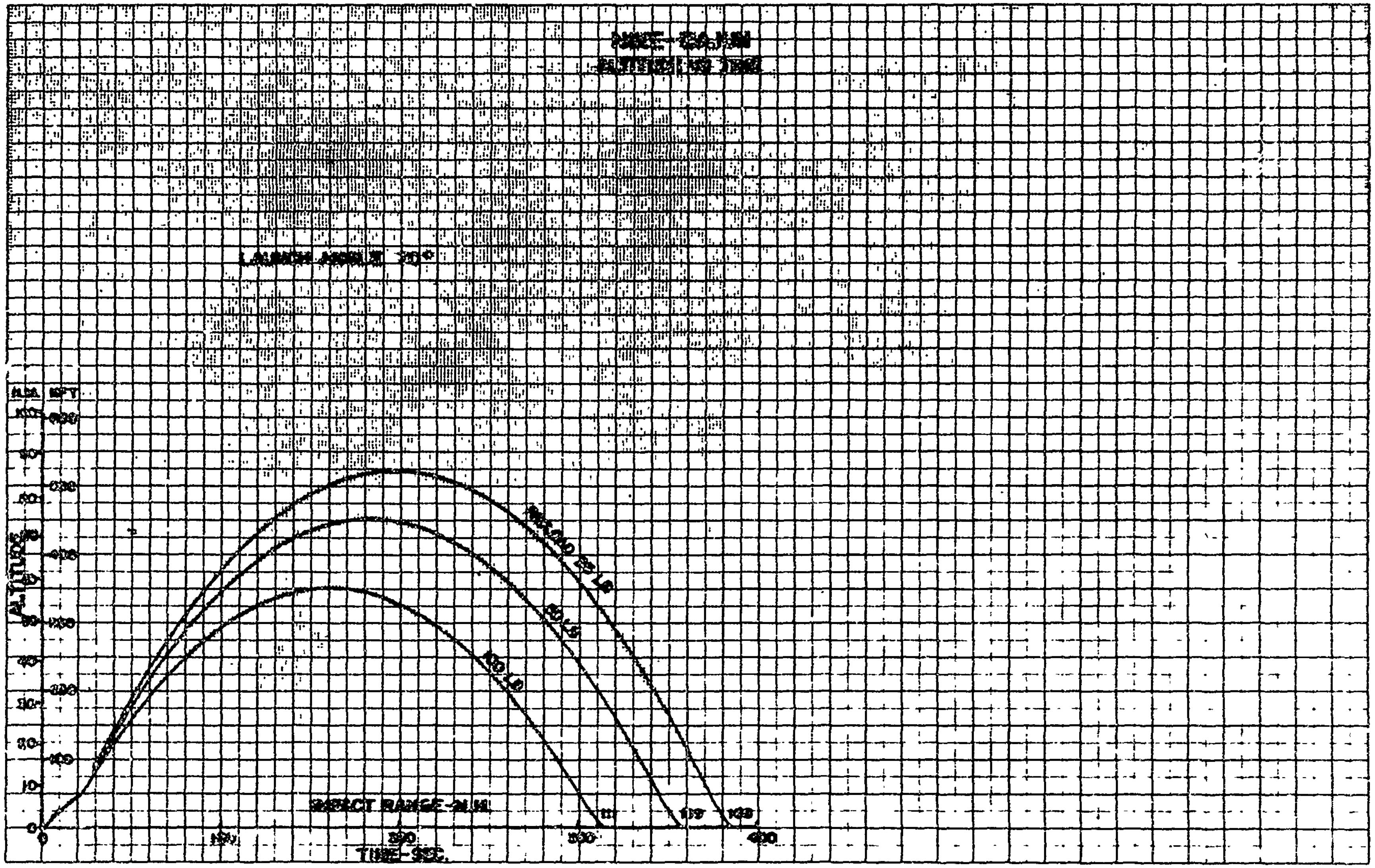

NIKE—CAJUN
PEAK ALTITUDE VS LAUNCH ANGLE
PEAK ALTITUDE
PAYLOAD
LAUNCH ANGLE (DEGREES)
70
75
80
85
90


NIKE—CAJUN

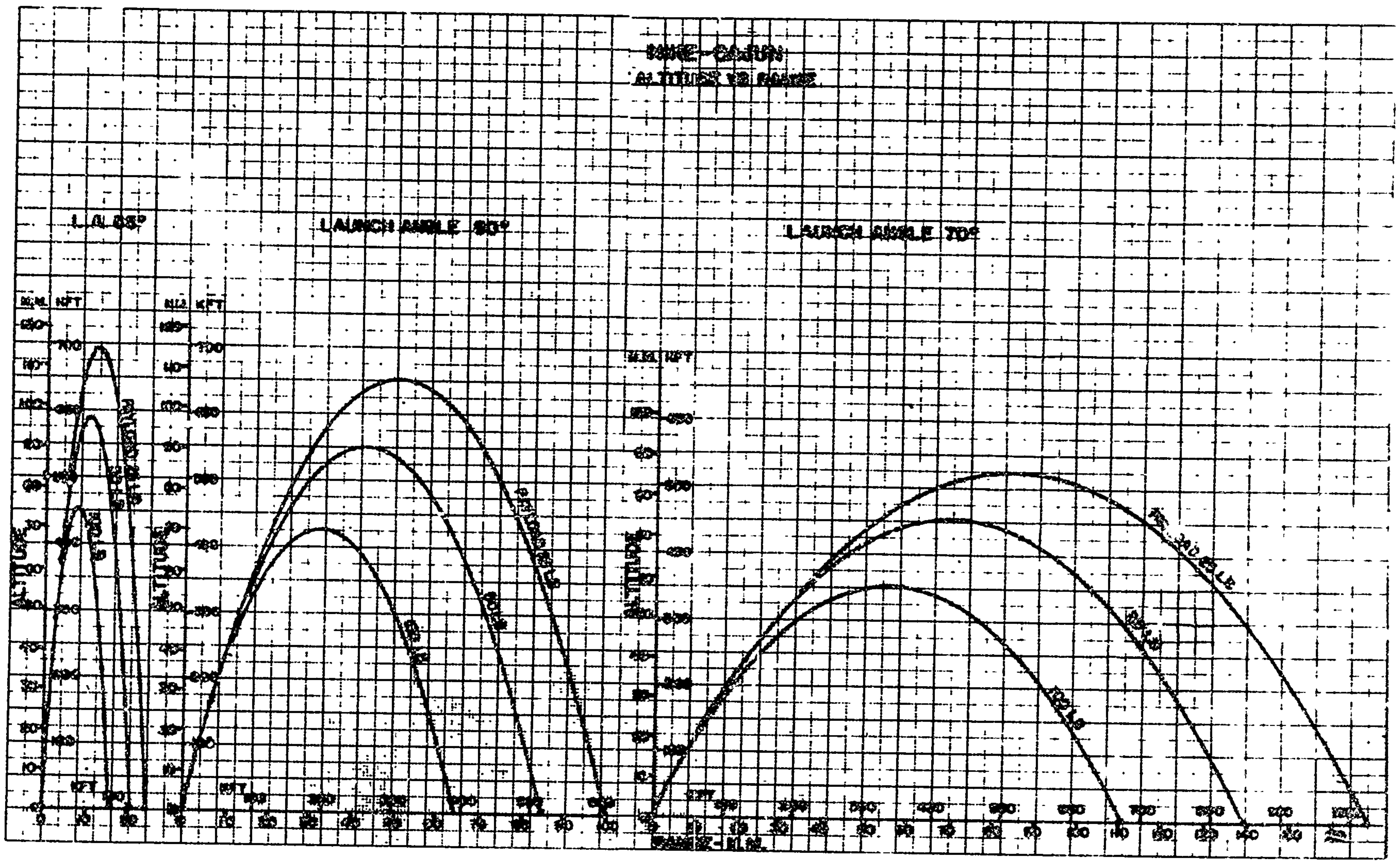


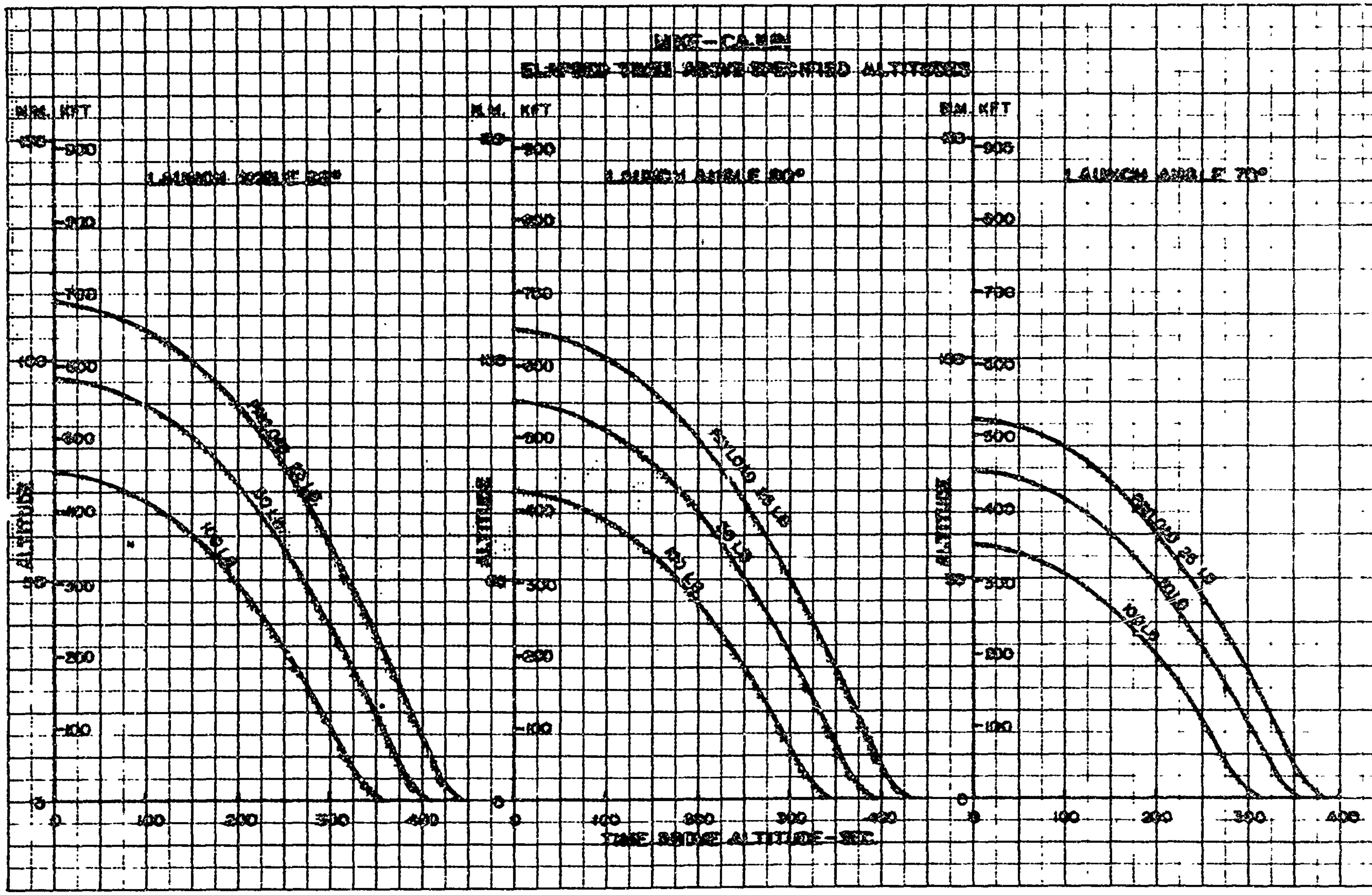
ALTITUDE VS TIME
ALTITUDE
TIME - SEC

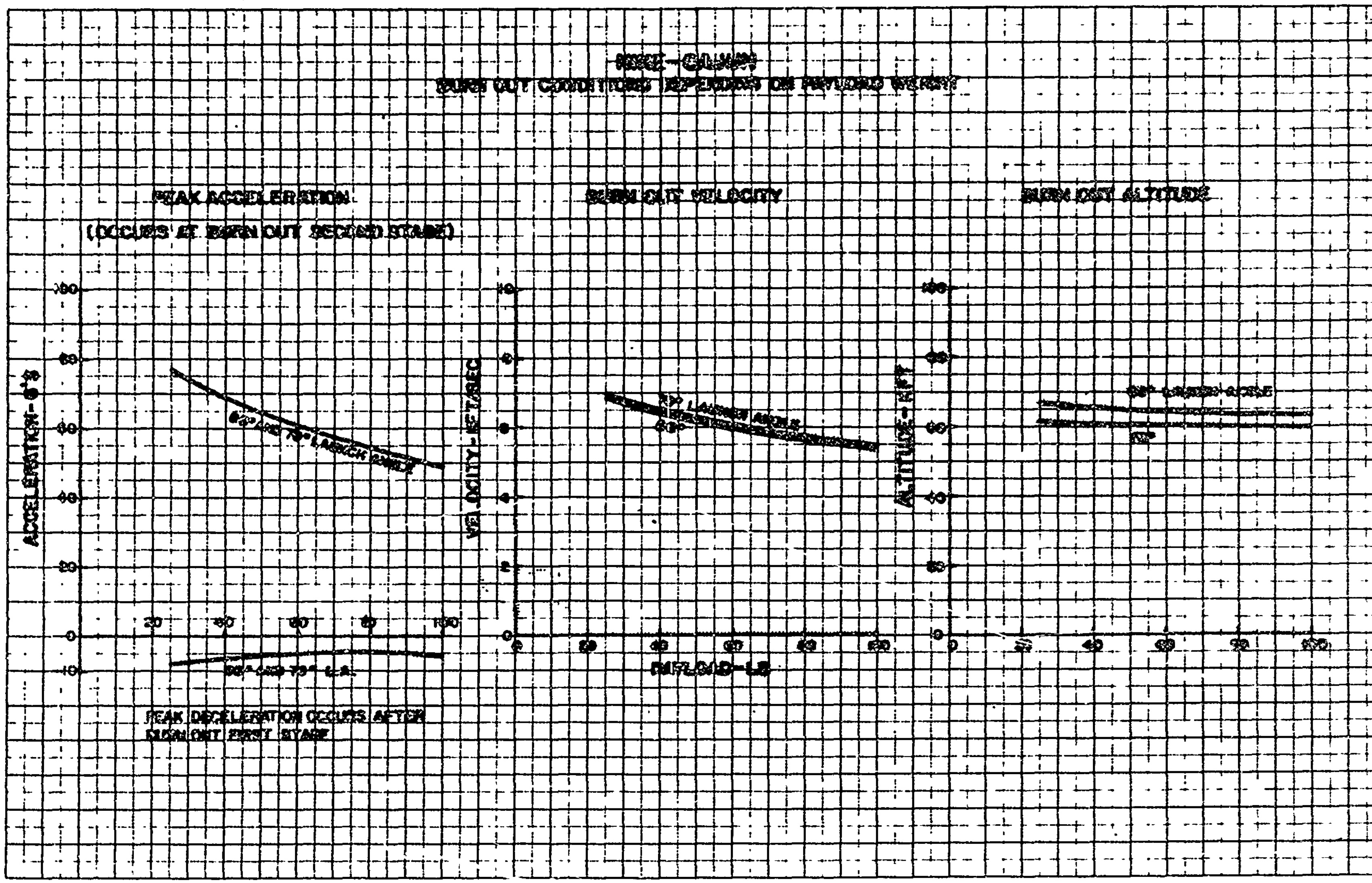
44

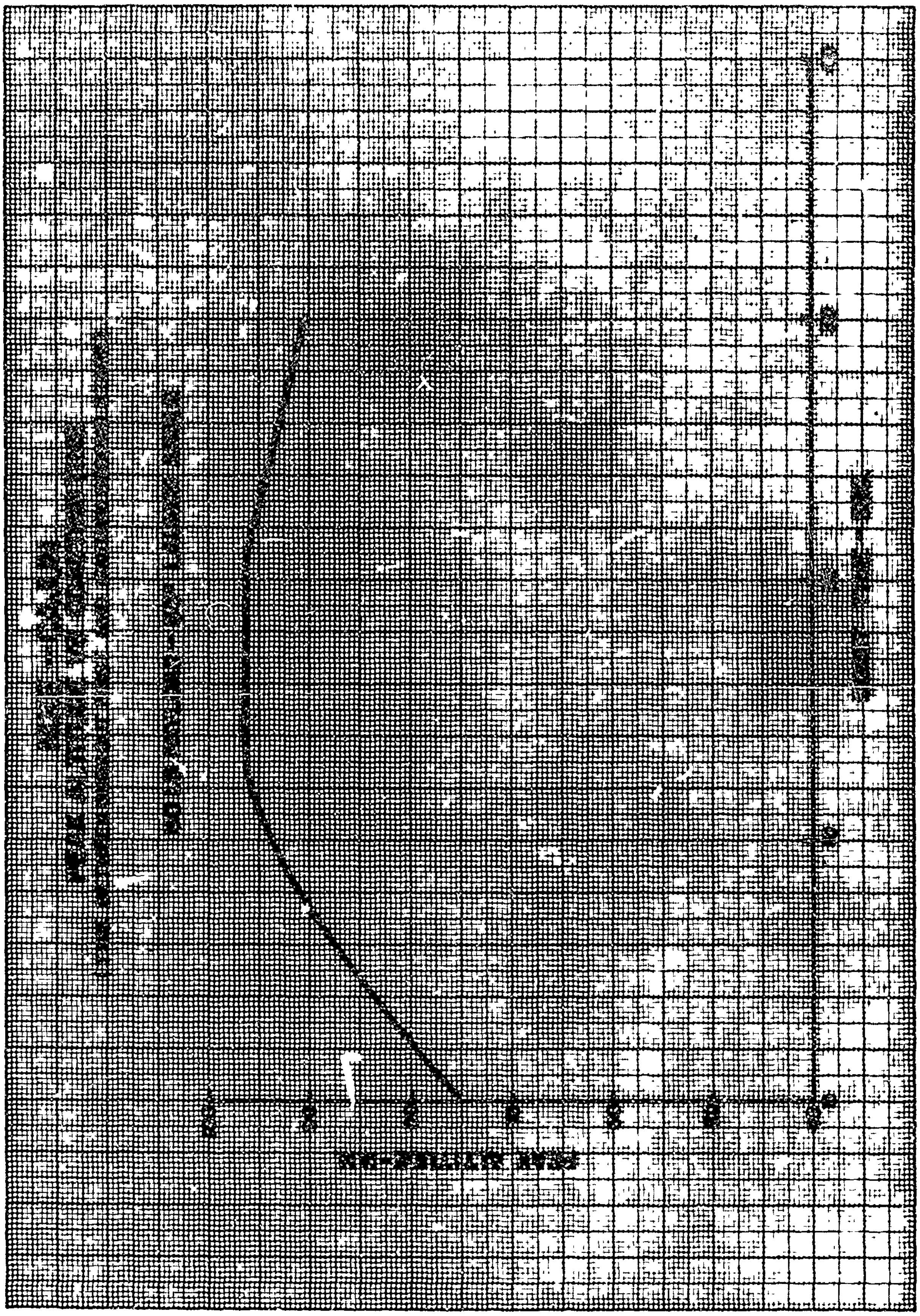


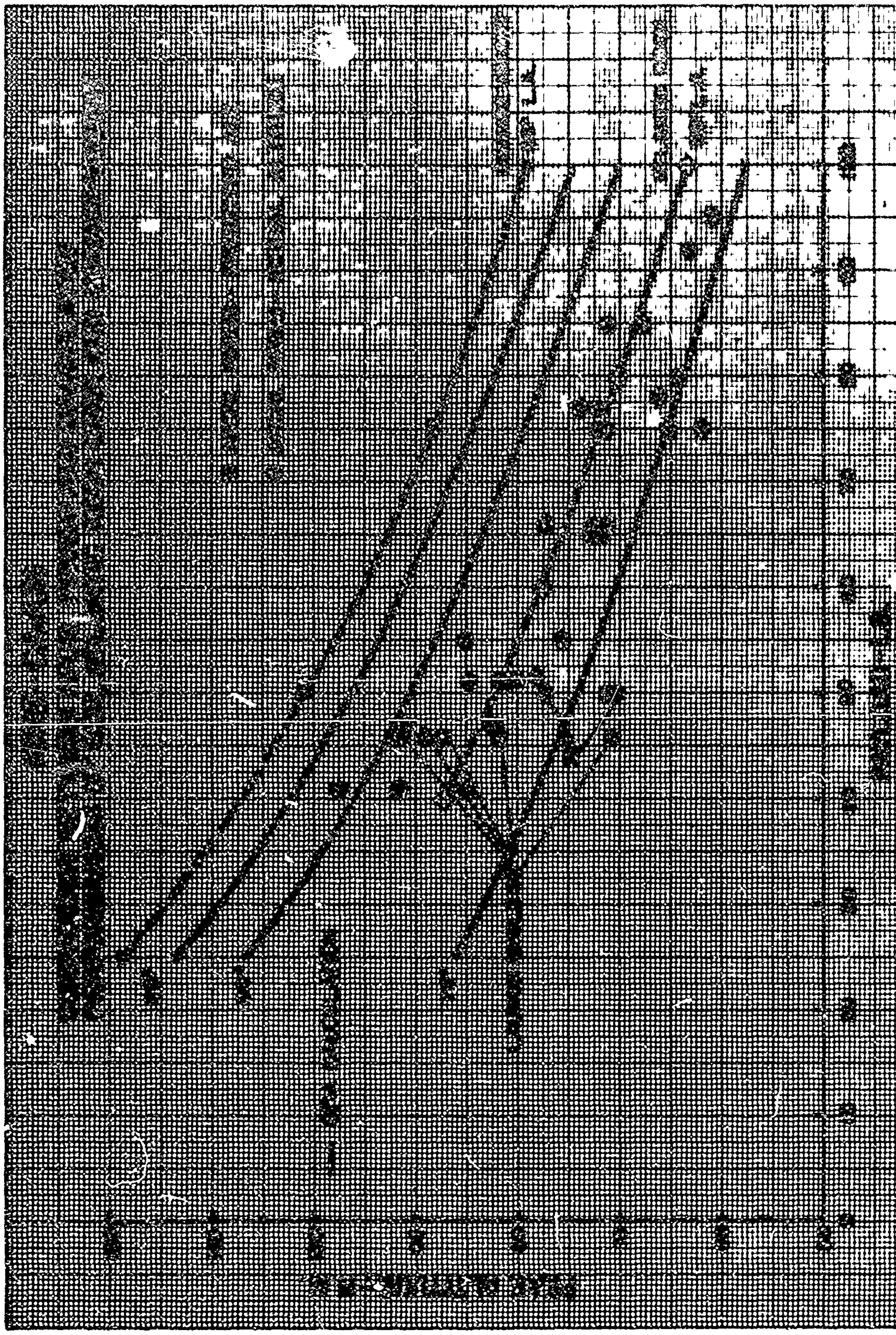
NIKE-CAJUN
ALTITUDE VS TIME
LAUNCH ANGLE 70°
ALTITUDE
N.MI.
K FT
PAYLOAD 25 LB
50 LB
100 LB
IMPACT RANGE-N.MI.
111
119
128
0
100
200
300
400
TIME-SEC.


NIKE-CAJUN
ALTITUDE VS RANGE
L.A. 85°
LAUNCH ANGLE 80°
LAUNCH ANGLE 70°
ALTITUDE
N.M.
KFT
RANGE - N.M.


ELAPSED TIME ABOVE SPECIFIED ALTITUDES
LAUNCH ANGLE 80°
LAUNCH ANGLE 70°
N.M.
KFT
ALTITUDE
10 LB
20 LB
PAYLOAD 25 LB
TIME ABOVE ALTITUDE-SEC.


BURN OUT CONDITIONS DEPENDING ON PAYLOAD WEIGHT
PEAK ACCELERATION
(OCCURS AT BURN OUT SECOND STAGE)
BURN OUT VELOCITY
BURN OUT ALTITUDE
ACCELERATION-G'S
VELOCITY-KFT/SEC
ALTITUDE-KFT
PAYLOAD-LB
PEAK DECELERATION OCCURS AFTER BURN OUT FIRST STAGE


PEAK ALTITUDE-KM



GROUND SUPPORT EQUIPMENT

For the assembly, checkout and launching of the Nike-Cajun the following equipment is required:

(1) Launcher

Two types of launchers have been used: the modified standard Nike loader/launcher available at Wallops Island and White Sands Missile Range (also used aboard USS Rushmore); and, the Ryan Aerolab general purpose launcher available at Eglin Air Force Base.

(2) Handling Equipment

The handling equipment consists partially of standard US Army equipment and equipment designed by the University of Michigan.

a. Booster Hoist Beam (A. O. No. Y 015-8003042) and Sling Assemblies (A. O. No. Y 015-8013975).

b. Missile Hand Lift Truck (A. O. No. Y 001-8001848) or any suitable fork lift truck.

c. Modified Bomb Lift Trailer, 4000 lb (AF Stock No. 8220-753300).

d. Cajun Cradle (Univ. of Michigan Drwg No. H5-40243).

e. Booster Cradle (Univ. of Michigan design).

f. Hand Booster Truck (A. O. No. Y 014-8001837).

g. Double Branch Sling Chain to lift the crated booster.

h. Electric Blanket and Winterization Kit, if required.

(3) Electrical Support Equipment to check igniter, circuity, firing squibs and second stage firing safety circuit.

AERODYNAMIC HEATING AND HEATING OF PAYLOAD COMPARTMENT

The aerodynamic heat input is small due to the short duration of the flight. The vehicle has been successfully flown in the higher payload range (90 lb) without any heat protection. Windtunnel tests at NASA indicate that in the range of 50 lb payload and below and for launch angles below 75°, heat protection is required for the leading edges of the Cajun fins and for the nose tip. Inconel cuffs are provided for these leading edges.

It should be noted that the internal heating of the payload depends on many factors like temperature at launch, heat output of the payload, outside air temperature during flight, aerodynamic heat input, heat input by sun radiation and earth albedo, heat insulation of the compartment, absorptivity, emissivity and heat conduction properties of the skin material, etc. Therefore, it is recommended to check the internal heating for every different payload and launch condition.

NIKE-APACHE

NIKE-APACHE

VEHICLE DESCRIPTION

Name of Vehicle	Nike-Apache
Designations	Nike-Apache, Mongoose II, Speedball II
Manufacturers	Aero Lab Development Company, Pasadena, California, Atlantic Research Corporation, Duarte, California; Zimney Corporation, Monrovia, California.
Kind of Vehicle	2 stage fin stabilized probe vehicle
First Stage Motor	Nike M5, 2.5 DS-59000 (X216-A2) Radford Arsenal
Second Stage Motor	Apache 5.35 KS-5200 Thiokol Chemical Corporation
Payload-Altitude Capability for 80° Launch Angle	25 lb - 168 N.M. 50 lb - 139 N.M. 100 lb - 103 N.M.
Payload Volume	0.347 - 1.0 cu ft
Peak Acceleration Peak Deceleration	47 G 8 G (25 lb payload 70°-88° L.A.)
Max Velocity	8100 FPS (25 lb 88° L.A.)
Launch Weight Less net payload	1526.6
Reliability	89%
Users	US Air Force, Army, Navy, NASA
Sources	Aero Lab, Atlantic Research, Ling-Temco-Vought, AFCRL, Army, NASA Performance Computation: AFMDC Analog Computation Branch

NIKE-APACHE

The Nike-Apache is closely related to the Nike-Cajun. The Apache motor has the same dimensions as the Cajun, but it has a modernized propellant which improves the peak altitude of the vehicle by approximately 35 percent. Because of the longer burning time, the peak accelerations have been decreased by approximately 40 percent. The fins of the Nike-Apache and Nike-Cajun vehicles are made interchangeable by most of the manufacturers.

Based on 18 firings, including AFCRL and NASA firings, the Nike-Apache has an excellent reliability record.

As in the case of the Nike-Cajun the ORA calculated performances appear too good when compared with performances obtained at actual firings. (See page 4-14). This and also the difference between NASA predicted and observed peak altitudes suggest that the low performance may be due to poor attitude. New fins under development at AFCRL, interchangeable between Apache and Cajun, are designed to improve flight stability and performance.

To obtain realistic performance data the use of 75° launch angle curves is recommended.

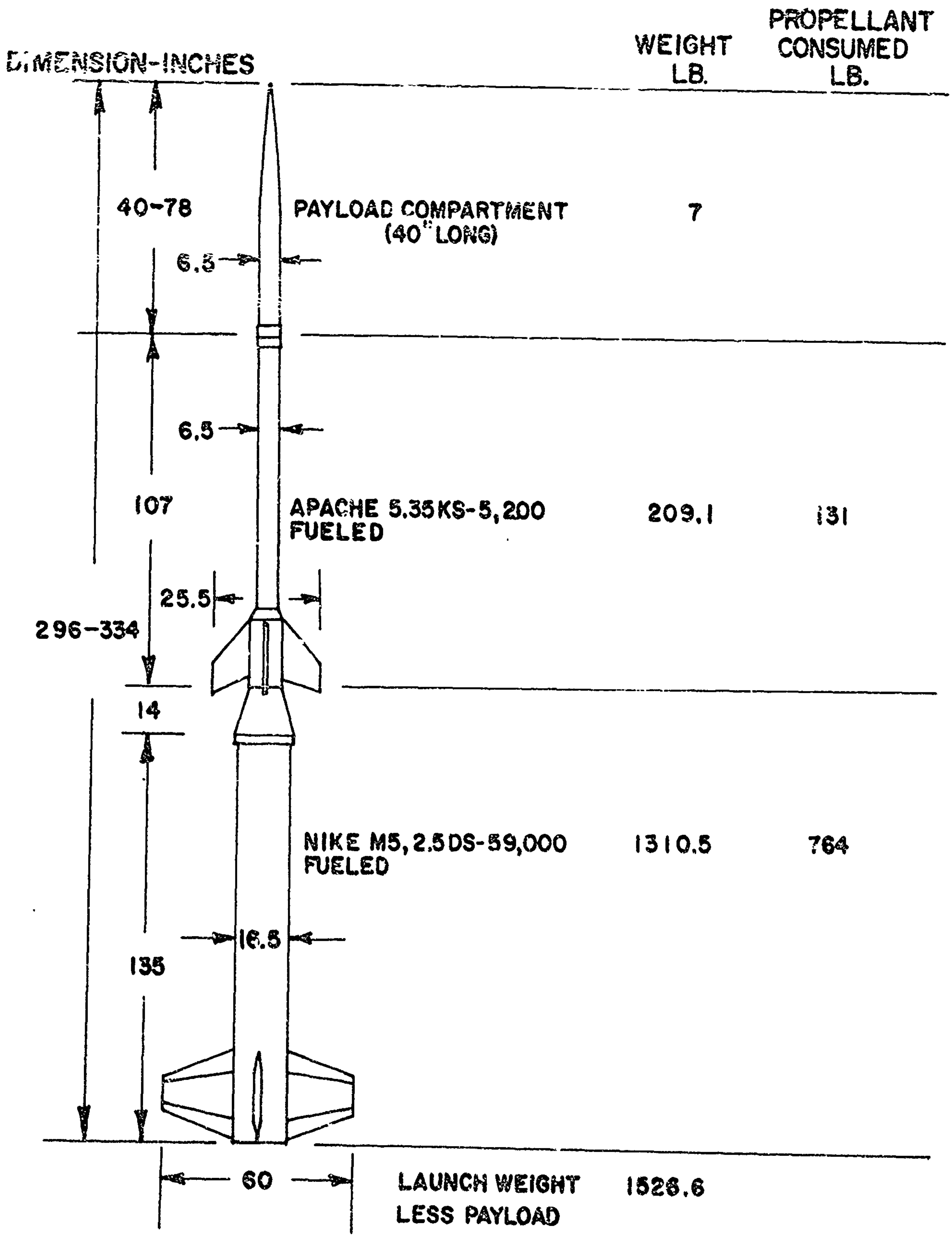
Firing Sequence: The first stage Nike motor burns for 3.5 seconds. Separation of first and second stage occurs at booster burnout by means of a slip-fit coupling and differential drag. The apogee altitude depends on the coasting time after first stage burnout. Peak altitude is reached with a coasting period of 16 seconds (for which the performances presented in this report were calculated). See graph on page 4-13). The second stage is ignited by a pyrotechnic delay squib and burns for 6.31 seconds.

Normally the Nike-Apache is adjusted for a no-spin condition. If spin stabilization is desired variable incidence fins for the Nike-booster and interchangeable spin tabs for the Apache-fins are offered by the manufacturers.

NIKE-APACHE

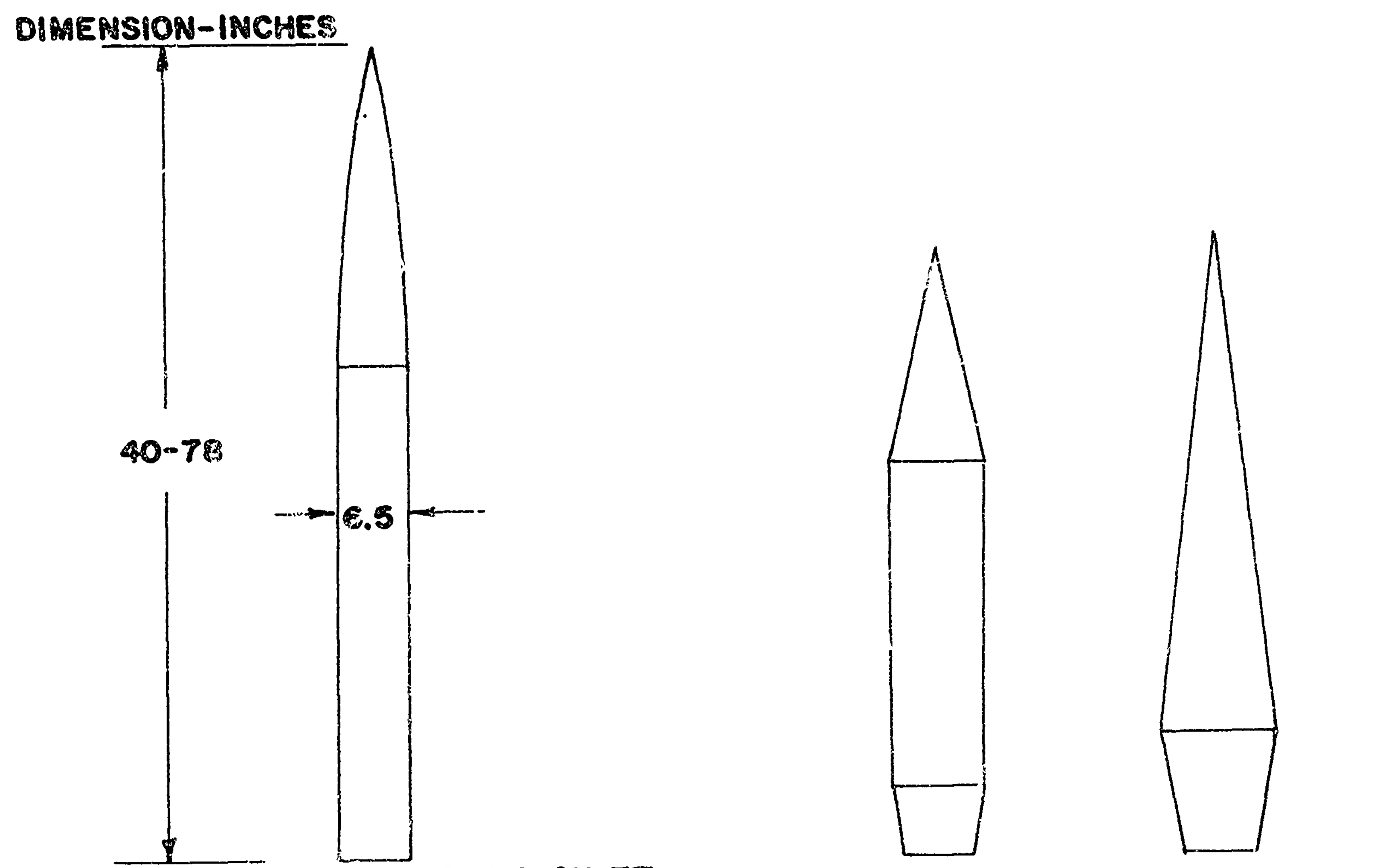
ASSEMBLY DIMENSIONS AND WEIGHTS

PAYLOAD 25-100 LB.



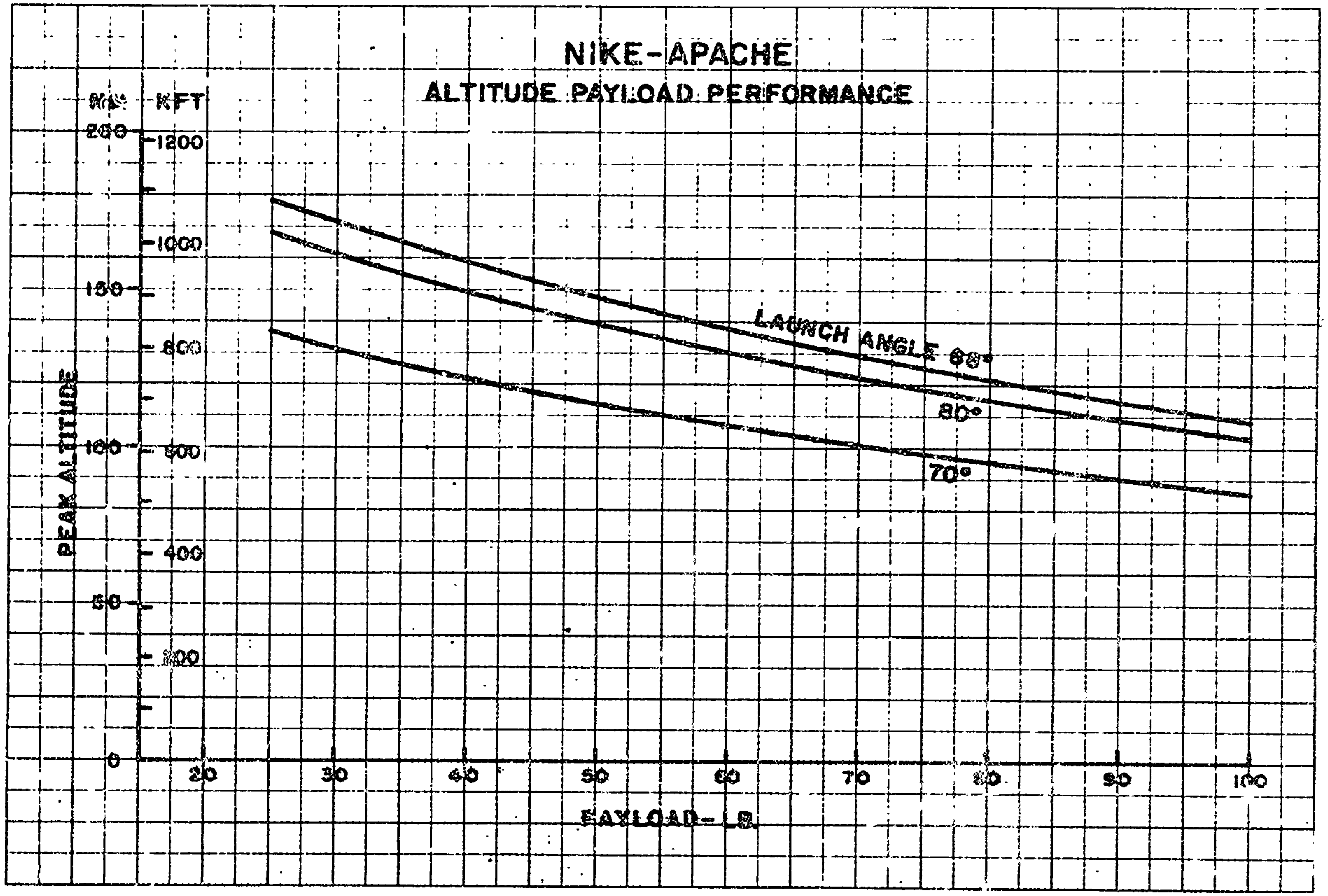
NIKE-APACHE

PAYLOAD COMPARTMENTS

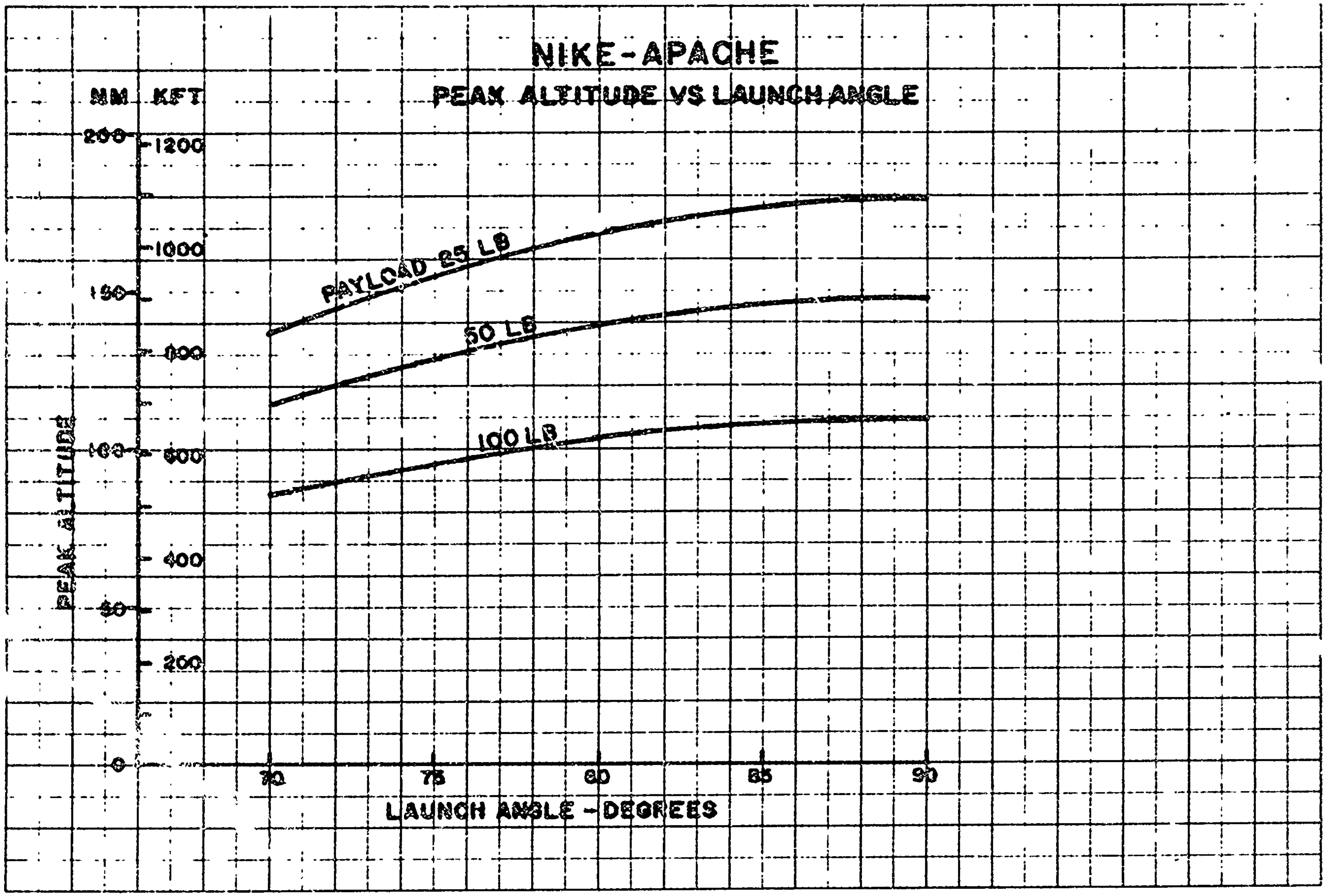


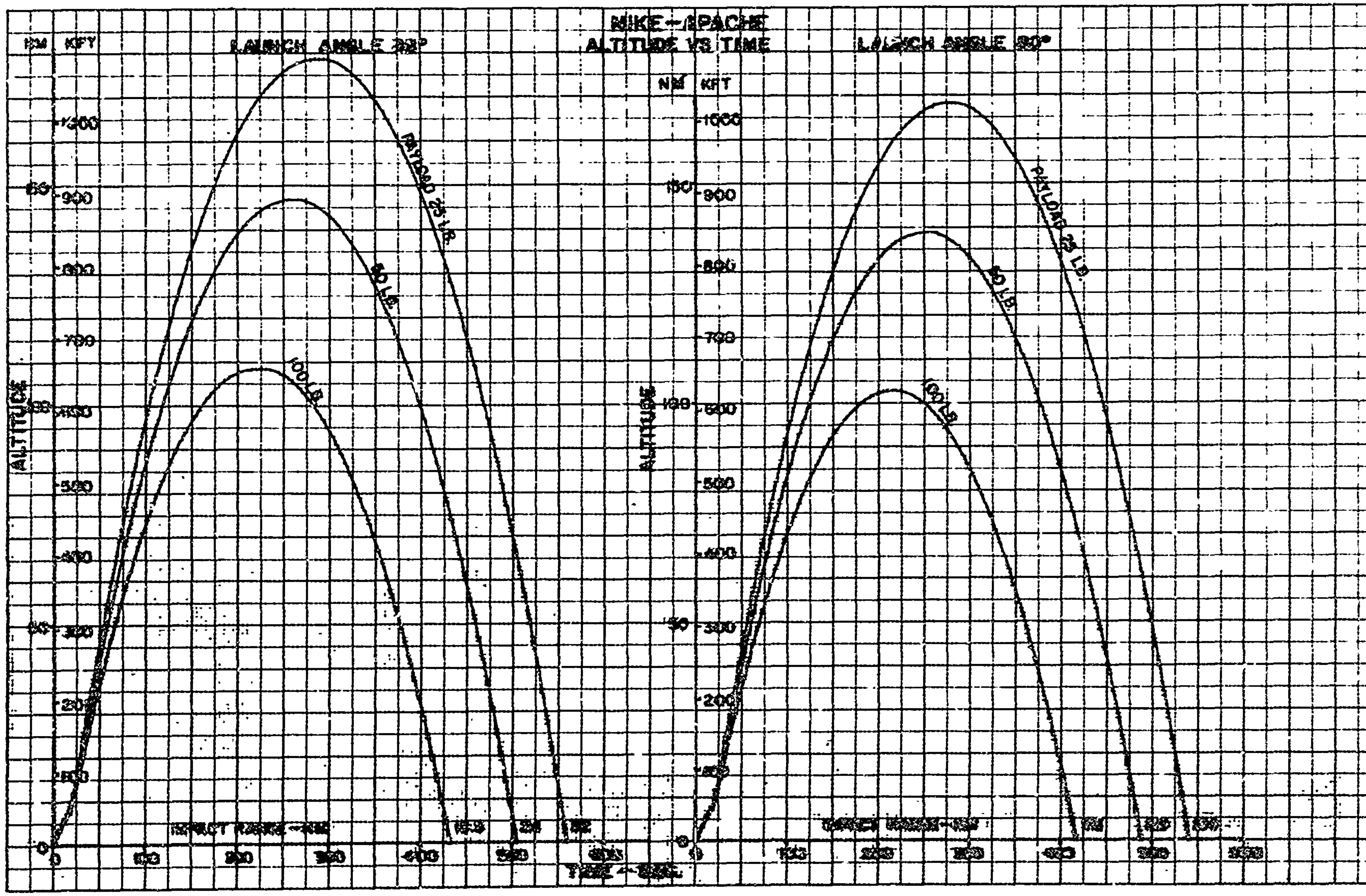
PAYLOAD VOLUME 0.347-1.0 CU.FT.

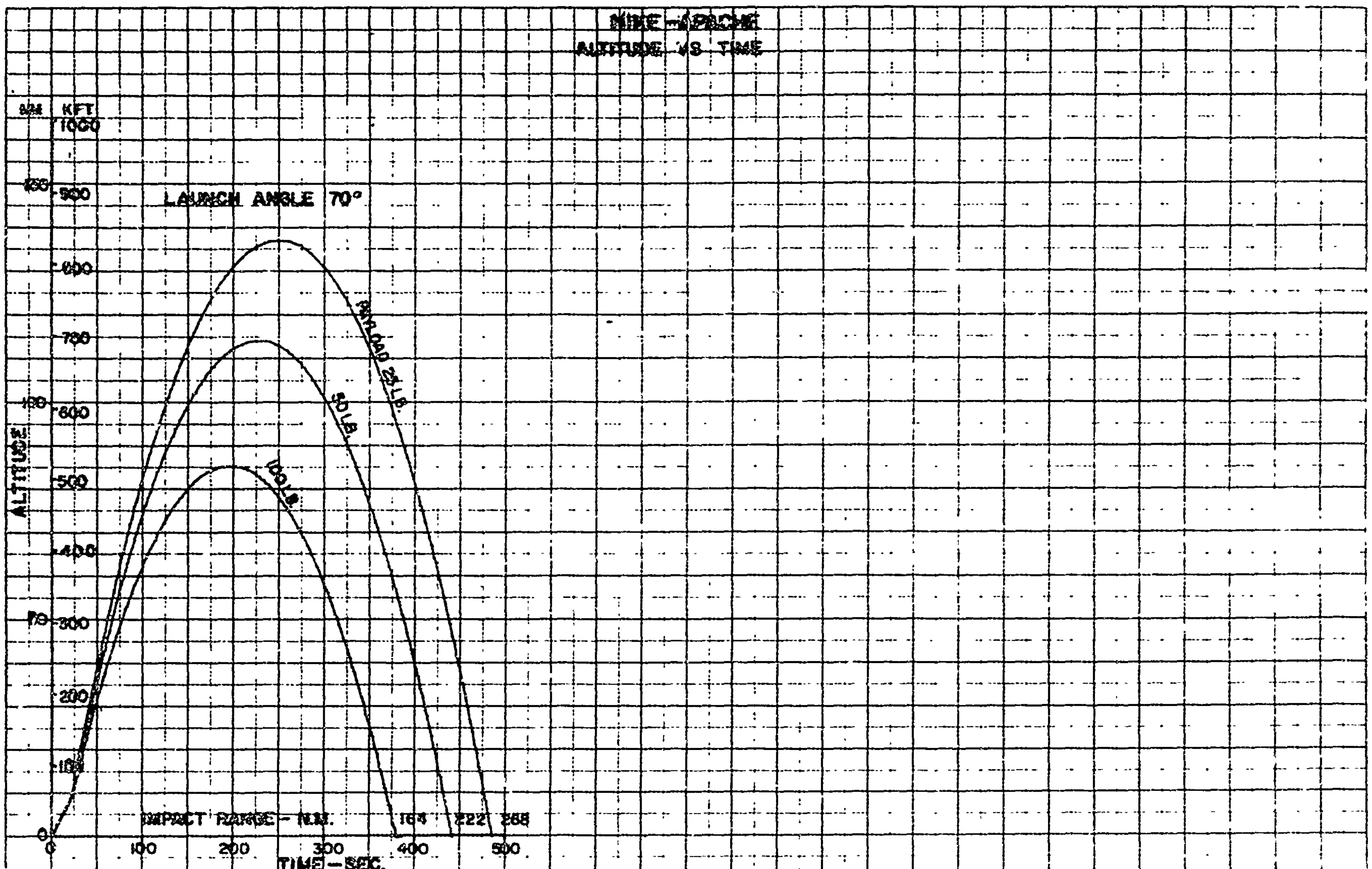
STANDARD SHAPE PAYLOAD COMPARTMENT OTHER CONFIGURATIONS IN USE

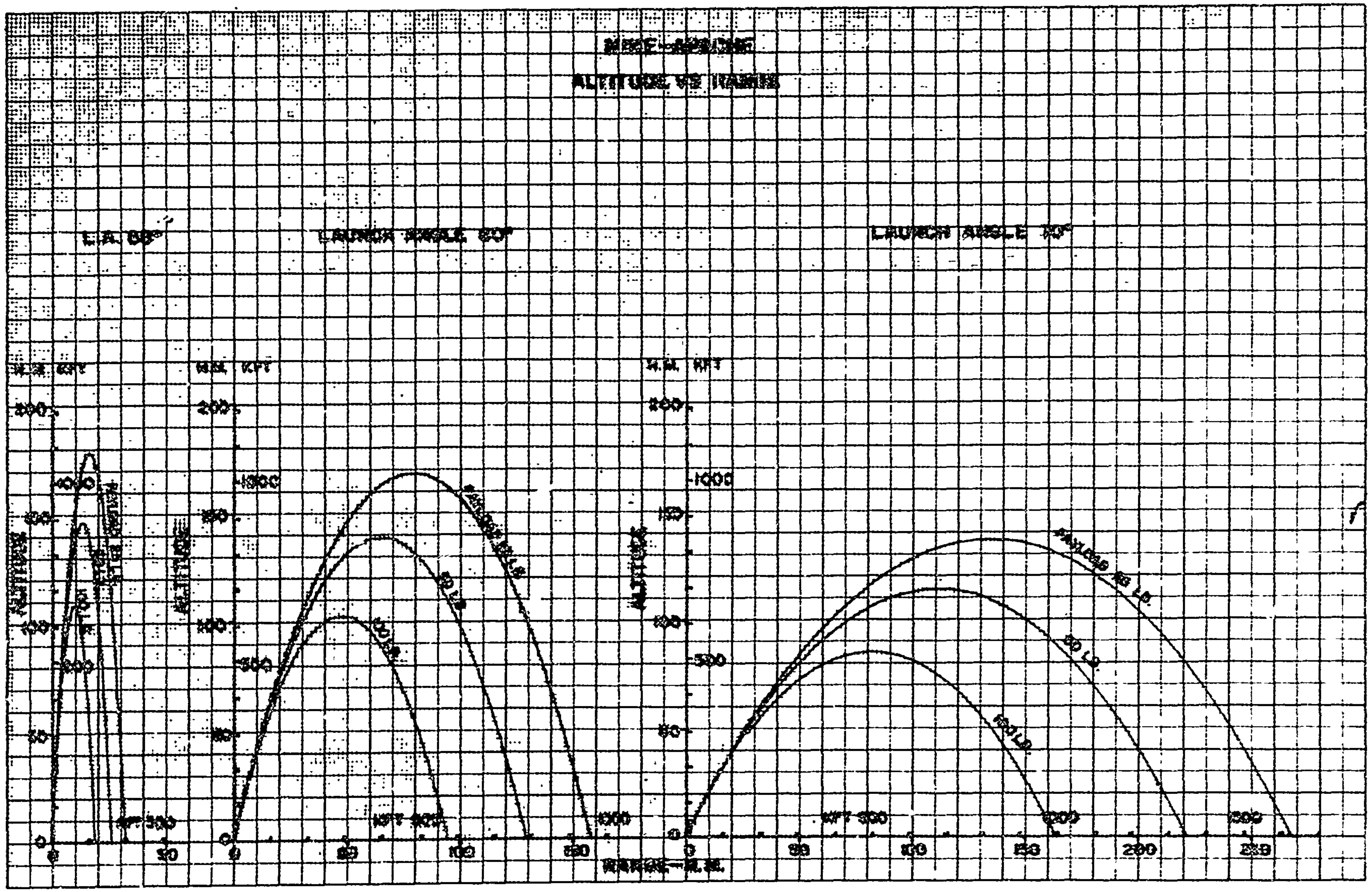


NIKE-APACHE
ALTITUDE PAYLOAD PERFORMANCE
KFT
200
150
100
50
0
1200
1000
800
600
400
200
PEAK ALTITUDE
LAUNCH ANGLE
80°
70°
20
30
40
50
60
70
80
90
100
PAYLOAD—LB

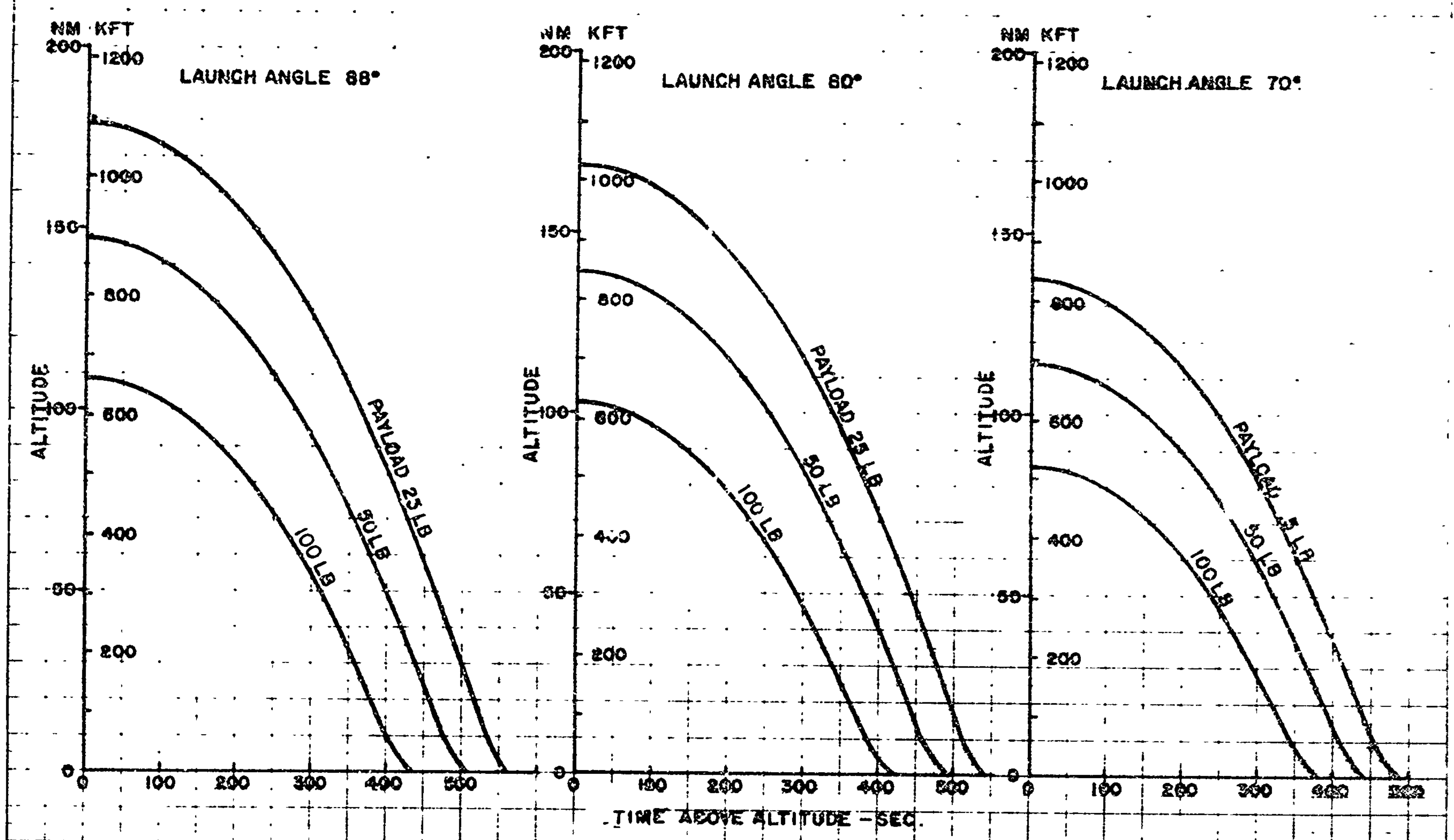

NIKE-APACHE
PEAK ALTITUDE VS LAUNCH ANGLE
NM
KFT
200
150
100
50
0
1200
1000
800
600
400
200
PEAK ALTITUDE
PAYLOAD 25 LB
50 LB
100 LB
70
75
80
85
90
LAUNCH ANGLE - DEGREES

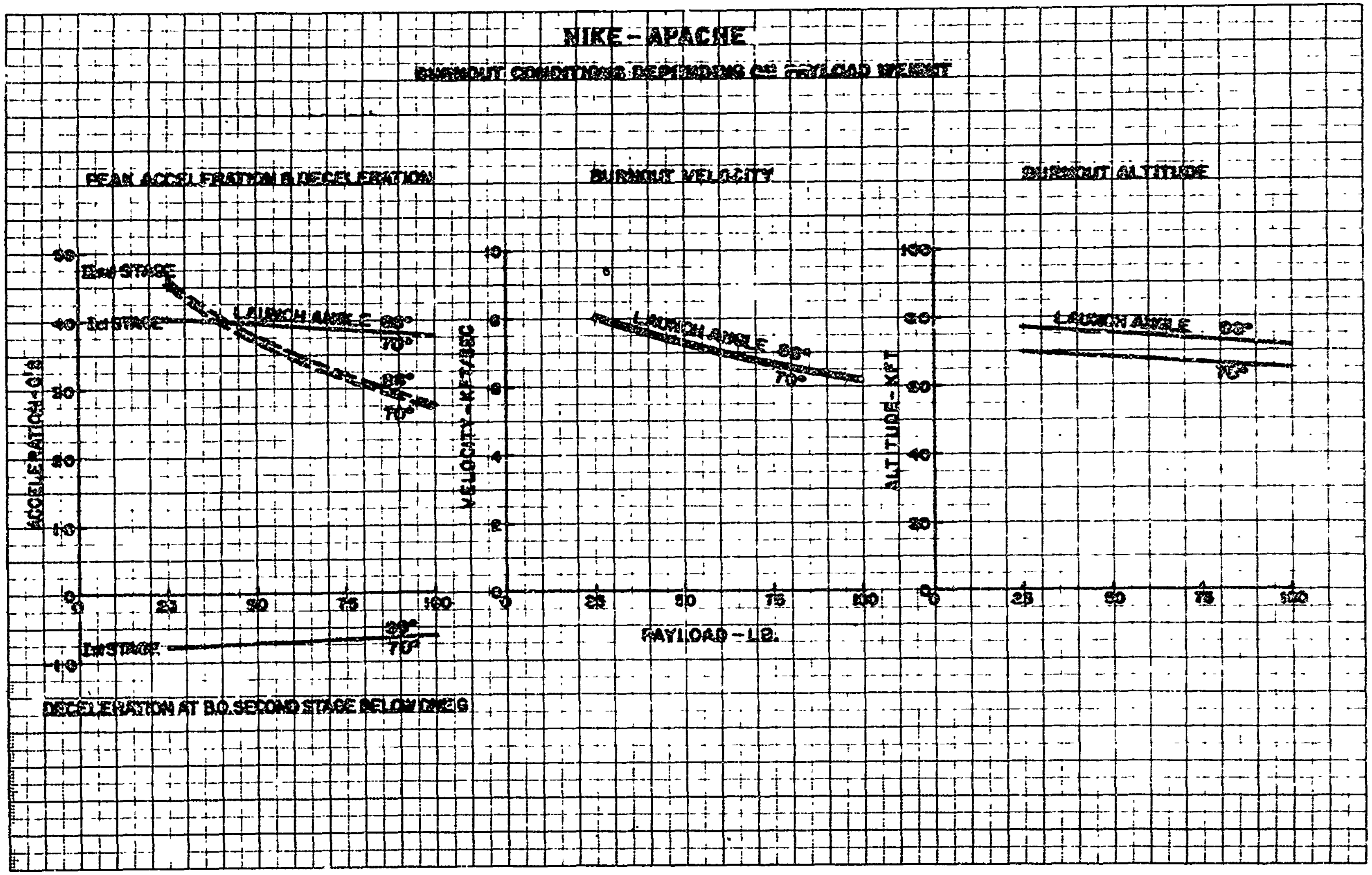

MIKE—APACHE
ALTITUDE VS TIME
NM KFT
ALTITUDE
PAYLOAD 25 LB.
50 LB.
100 LB.
TIME—SEC.

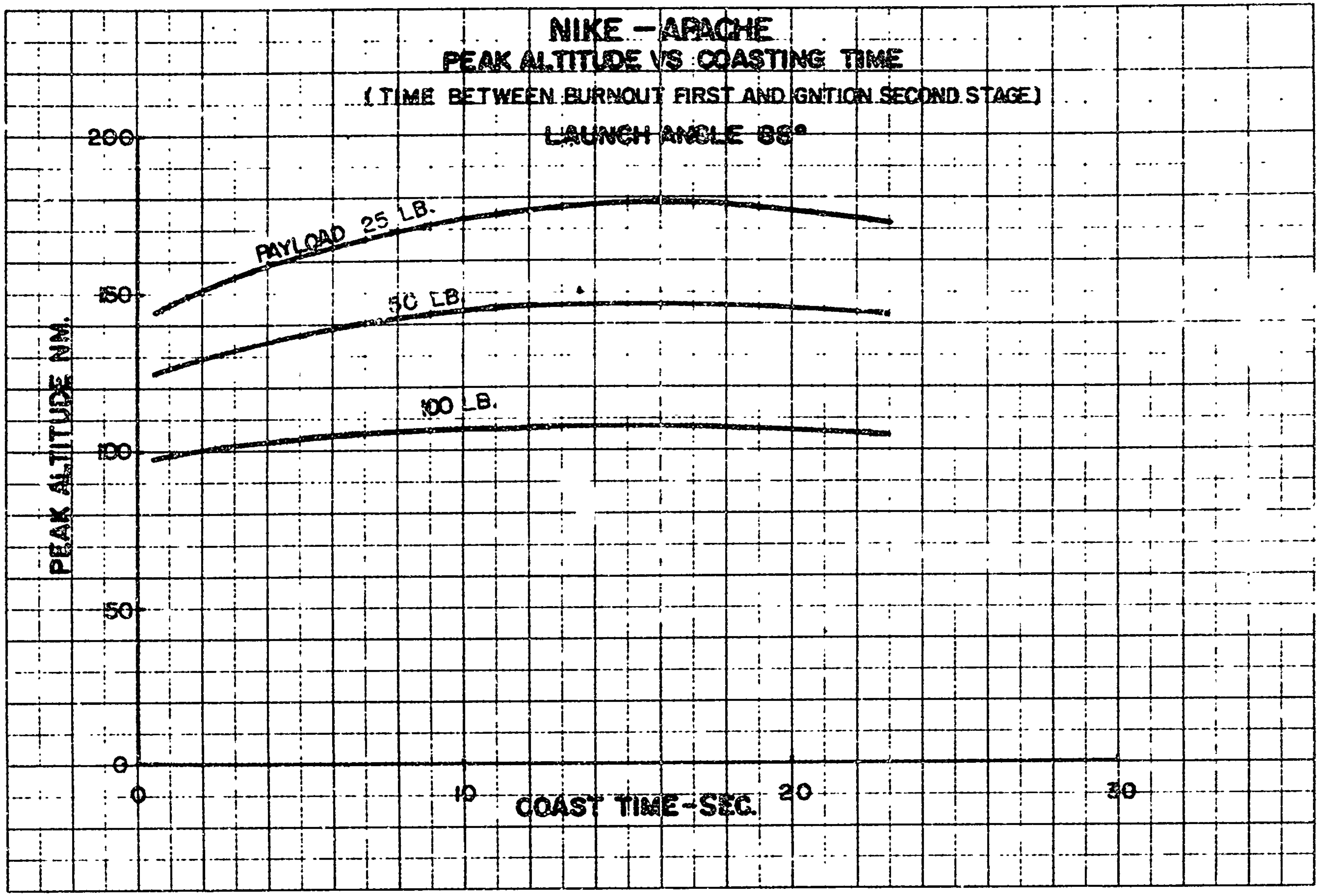

NIKE-APACHE
ALTITUDE VS TIME
N/M KFT
LAUNCH ANGLE 70°
PAYLOAD 25 LB.
50 LB.
100 LB.
ALTITUDE
IMPACT RANGE - N.M.
164 222 268
0 100 200 300 400 500
TIME—SEC.
1000 900 800 700 600 500 400 300 200 100 0
150 100 50

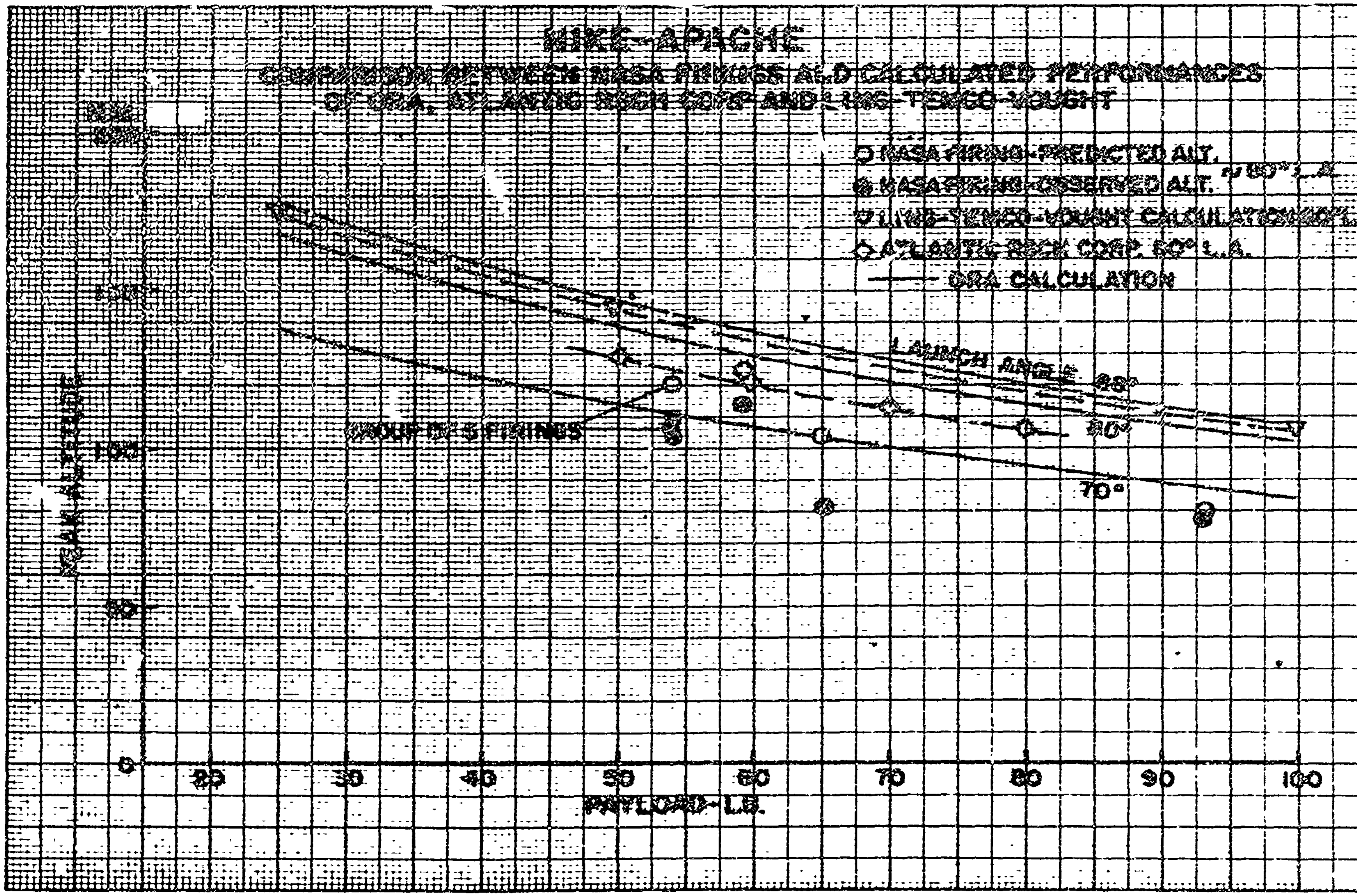

NIKE-APACHE
ALTITUDE VS RANGE
ALTITUDE
N.M. KFT
PAYLOAD 60 LB.
80 LB.
100 LB.
RANGE—N.M.

NIKE-APACHE
ELAPSED TIMES ABOVE SPECIFIED ALTITUDES




NIKE - APACHE
BURNOUT CONDITIONS DEPENDING ON PAYLOAD WEIGHT
MEAN ACCELERATION & DECELERATION
BURNOUT VELOCITY
BURNOUT ALTITUDE
2nd STAGE
1st STAGE
LAUNCH ANGLE 85°
70°
ACCELERATION-G'S
VELOCITY-KFT/SEC
ALTITUDE-KFT
PAYLOAD - LB.
DECELERATION AT B.O. SECOND STAGE BELOW ONE G
0
25
50
75
100
10
20
30
40
50
60
80
2
4
6
8


NIKE — APACHE
PEAK ALTITUDE VS COASTING TIME
(TIME BETWEEN BURNOUT FIRST AND IGNITION SECOND STAGE)
LAUNCH ANGLE 86°
PEAK ALTITUDE NM.
200
150
100
50
0
PAYLOAD 25 LB.
50 LB.
100 LB.
0
10
20
30
COAST TIME-SEC.



NIKE-APACHE
COMPARISON BETWEEN NASA FIRINGS AND CALCULATED PERFORMANCES
OF GRA, ATLANTIC RSCH CORP AND LING-TEMCO-VOUGHT
○ NASA FIRING-PREDICTED ALT.
● NASA FIRING-OBSERVED ALT.
▽ LING-TEMCO-VOUGHT CALCULATION
◇ ATLANTIC RSCH CORP. 60° L.A.
GRA CALCULATION
LAUNCH ANGLE
85°
80°
70°
GROUP OF 5 FIRINGS
PEAK ALTITUDE
150
100
50
0
20
30
40
50
60
70
80
90
100
PAYLOAD-LB.

GROUND SUPPORT EQUIPMENT

The Nike-Apache has been flown from many launching sites. The same launchers and handling equipment may be used as described under Nike-Cajun.

AERODYNAMIC HEATING AND HEATING OF PAYLOAD COMPARTMENT

The aerodynamic heat input is small due to the short duration of the flight. In the payload range below 50 pounds and at launch angles below 75° heat protection for the nose tip might be required depending on the material used. Payload housings are offered in aluminum, stainless steel, inconel and fiberglass.

The internal heating of the payload compartment depends on factors like temperature at launch, heat output of payload, outside air temperatures during flight, aerodynamic heat input, sun radiation, heat insulation of the compartment, absorptivity, emissivity and heat conduction properties of the skin material. It is therefore recommended to check the internal heating for every different payload and launch condition.

IRIS

VEHICLE DESCRIPTION

Name of Vehicle	Iris
Manufacturer	Atlantic Research Corporation Alexandria, Virginia
Kind of Vehicle	2 stage fin stabilized probe vehicle
First Stage Motor	0.8-KS-18800, Marc 14B1, Atl Rsch (Cluster of seven 0.8 KS-2700)
Second Stage Motor	51.6-KS-3850, Marc 13A1, Atl Rsch
Payload-Altitude Capability for 88° Launch Angle	75 lb - 185 N. M. 100 lb - 167 N. M. 200 lb - 117 N. M.
Payload Volume	4.55 cu ft standard compartment 5.86 cu ft stand comp plus extension
Peak Acceleration	14 G (75 lb payload, 70°-88° L. A.)
Max. Velocity	7730 FPS (25 lb payload, 88° L. A.)
Launch Weight less net payload	1419.0 lb
Reliability	2 successes out of 3 firings
Users	NASA
Sources	Atlantic Research, Chance-Vought, NASA. Performance computation: AFMDC Analog Computation Branch.

IRIS

The Iris sounding rocket, a development of the Atlantic Research Corporation, was initiated in 1956 by the Naval Research Laboratories and completed under NASA sponsorship in 1961. Only 3 vehicles have been fired in performance flight tests.

The Iris is a four finned, two stage solid propellant rocket designed to be launched from the 160 ft Aerobee tower at Wallops Island. A three finned version has been offered by the manufacturer but has never been built. The first stage consists of a cluster of seven 4 inch diameter rockets. Its purpose is to decrease the wind sensitivity of the vehicle by increasing the exit velocity from the tower. There is no mechanical connection between first and second stage. The first stage falls away as the vehicle leaves the tower. The second and main stage is an end-burner having relatively low thrust and accordingly low acceleration. Like the Aerobee 150 the vehicle is suitable for more delicate payloads.

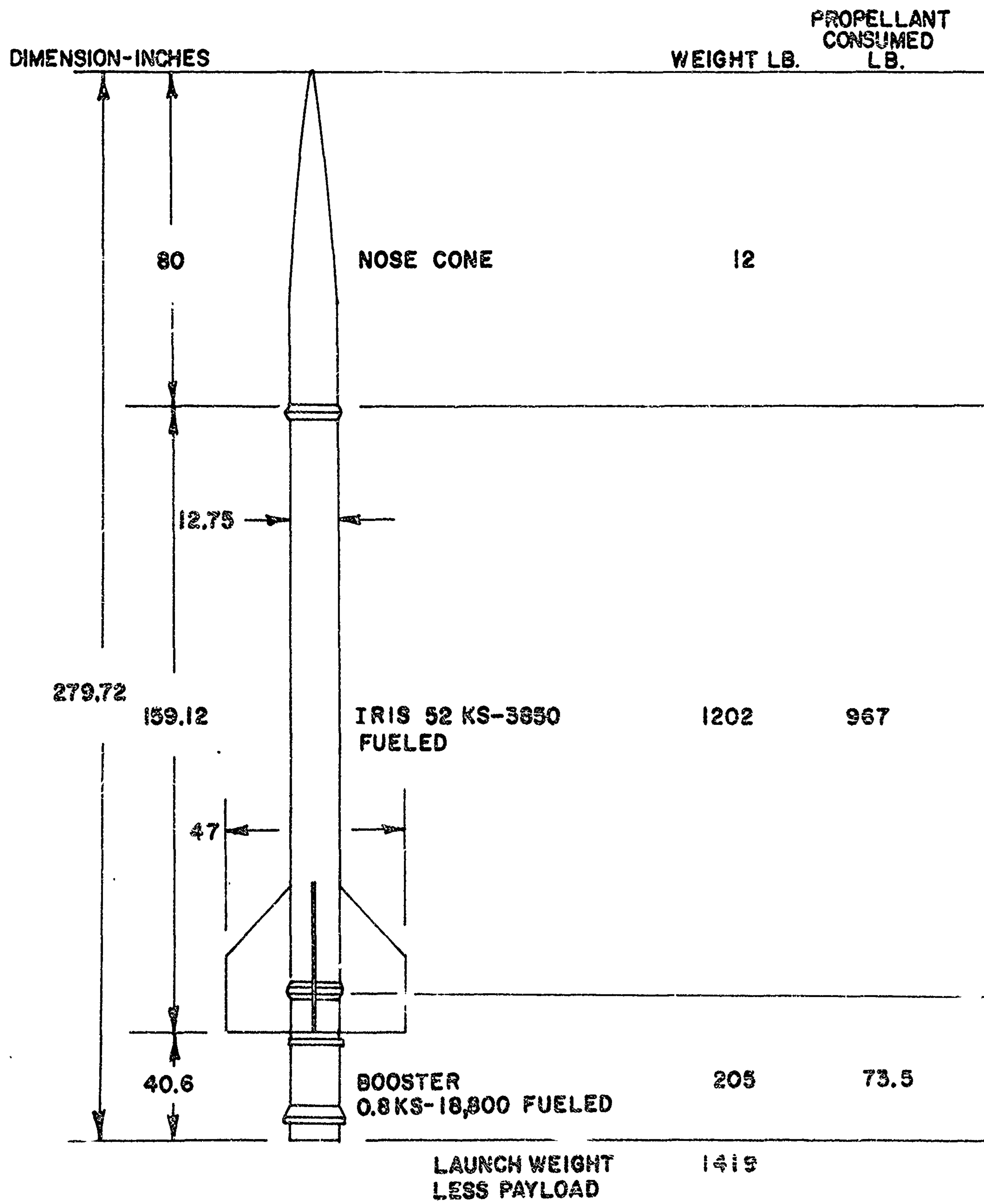
The firing sequence is as follows: first and second stage are ignited nearly simultaneously. With a small time delay for the second stage, in the order of milliseconds, they burn together until booster burnout at 0.81 seconds. The booster then drops away and the second stage keeps on burning for an additional 61.19 seconds. The total burning time is 62 seconds.

The launch angles of the Iris are restricted to values above 80°, due to restrictions in the Aerobee launch tower used.

IRIS

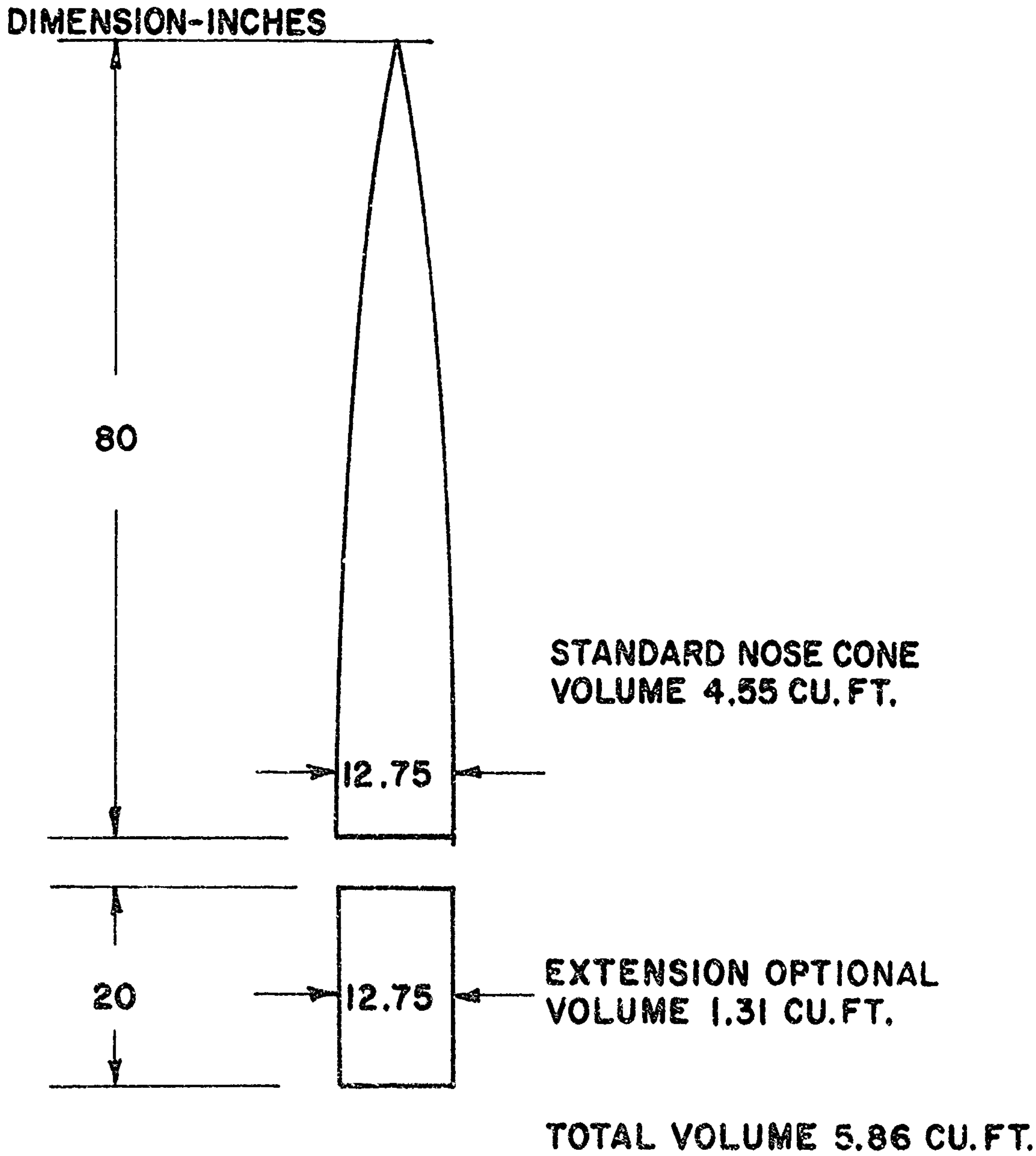
ASSEMBLY, DIMENSIONS AND WEIGHTS

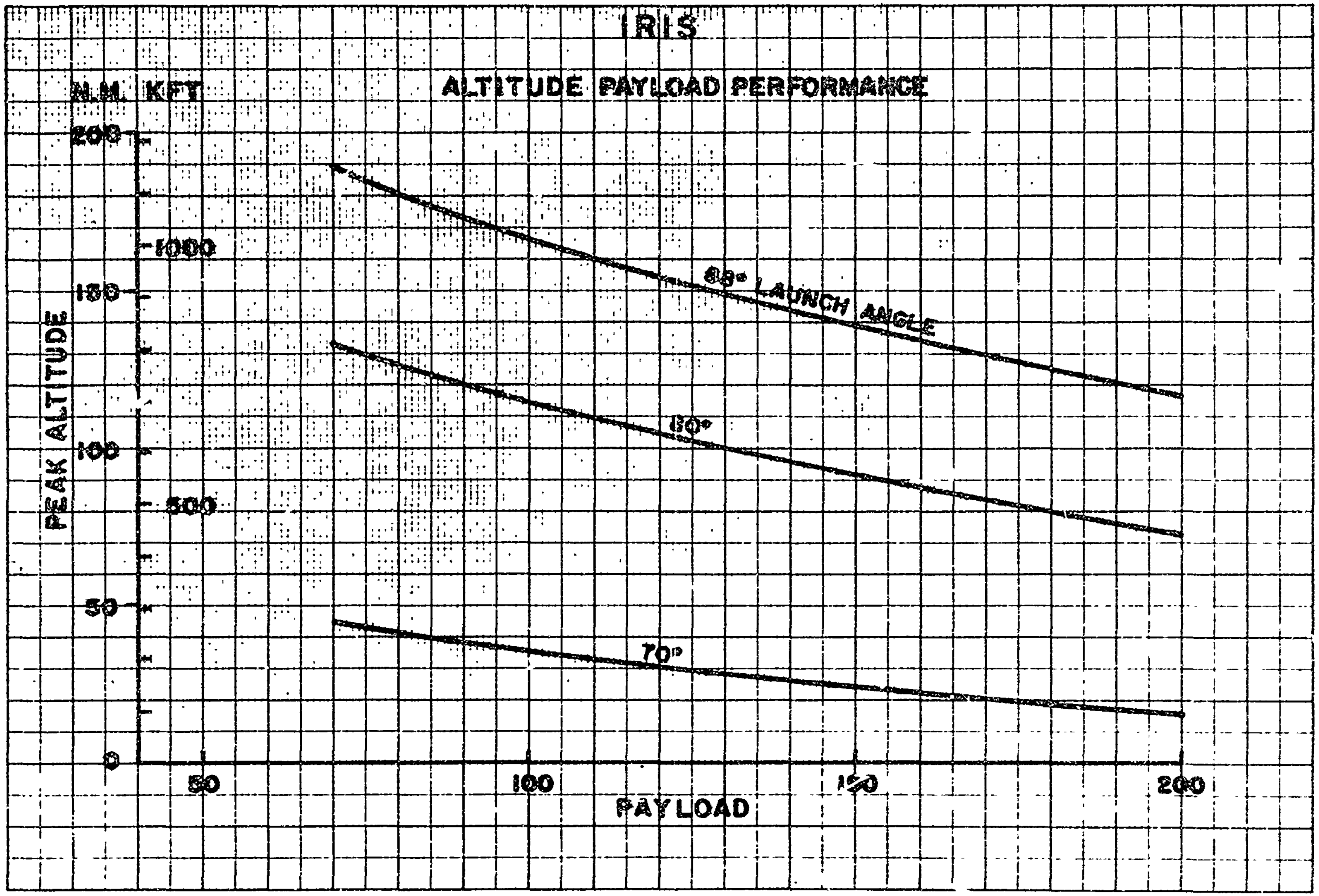
PAYLOAD 75-200 LB.



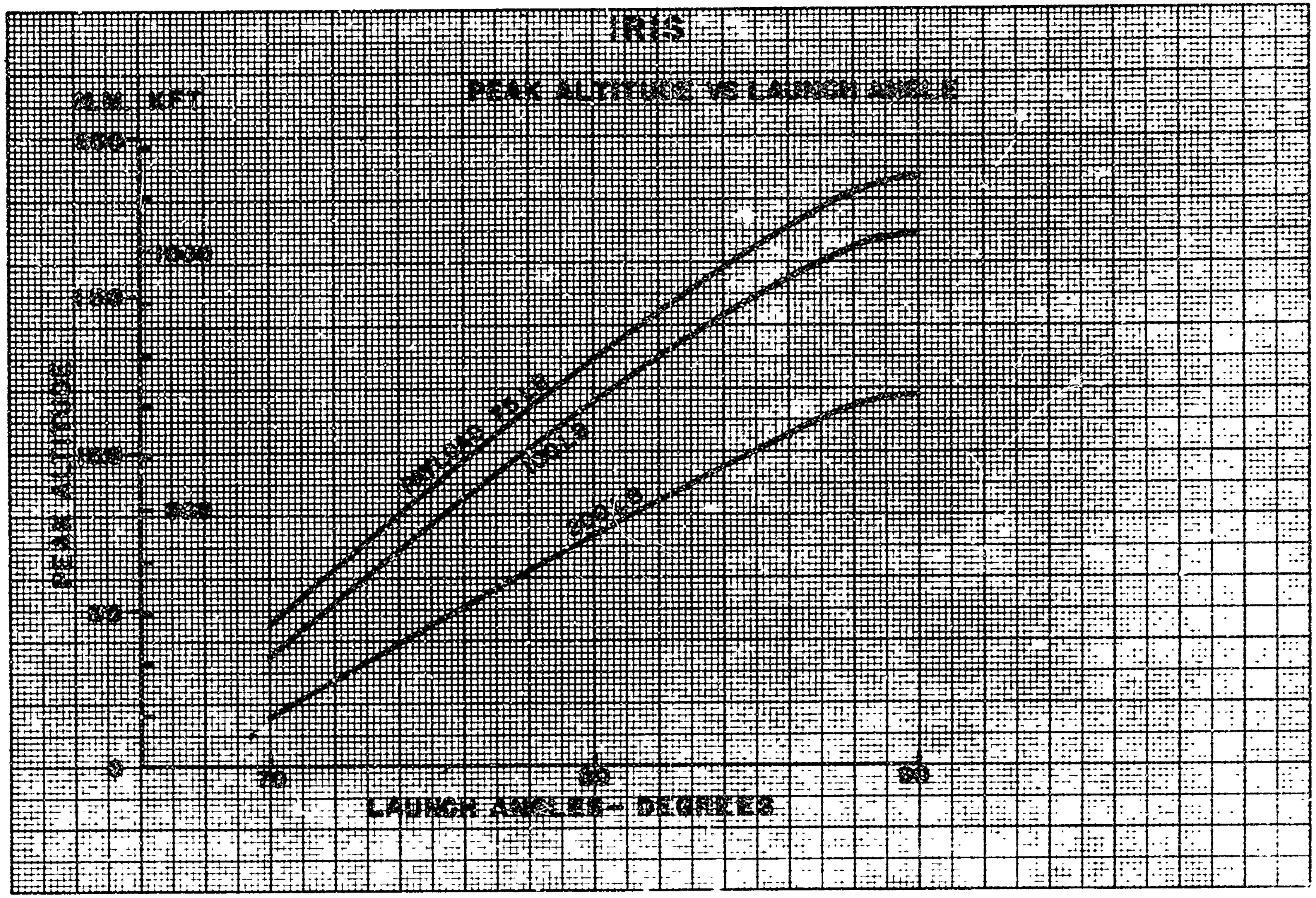
IRIS

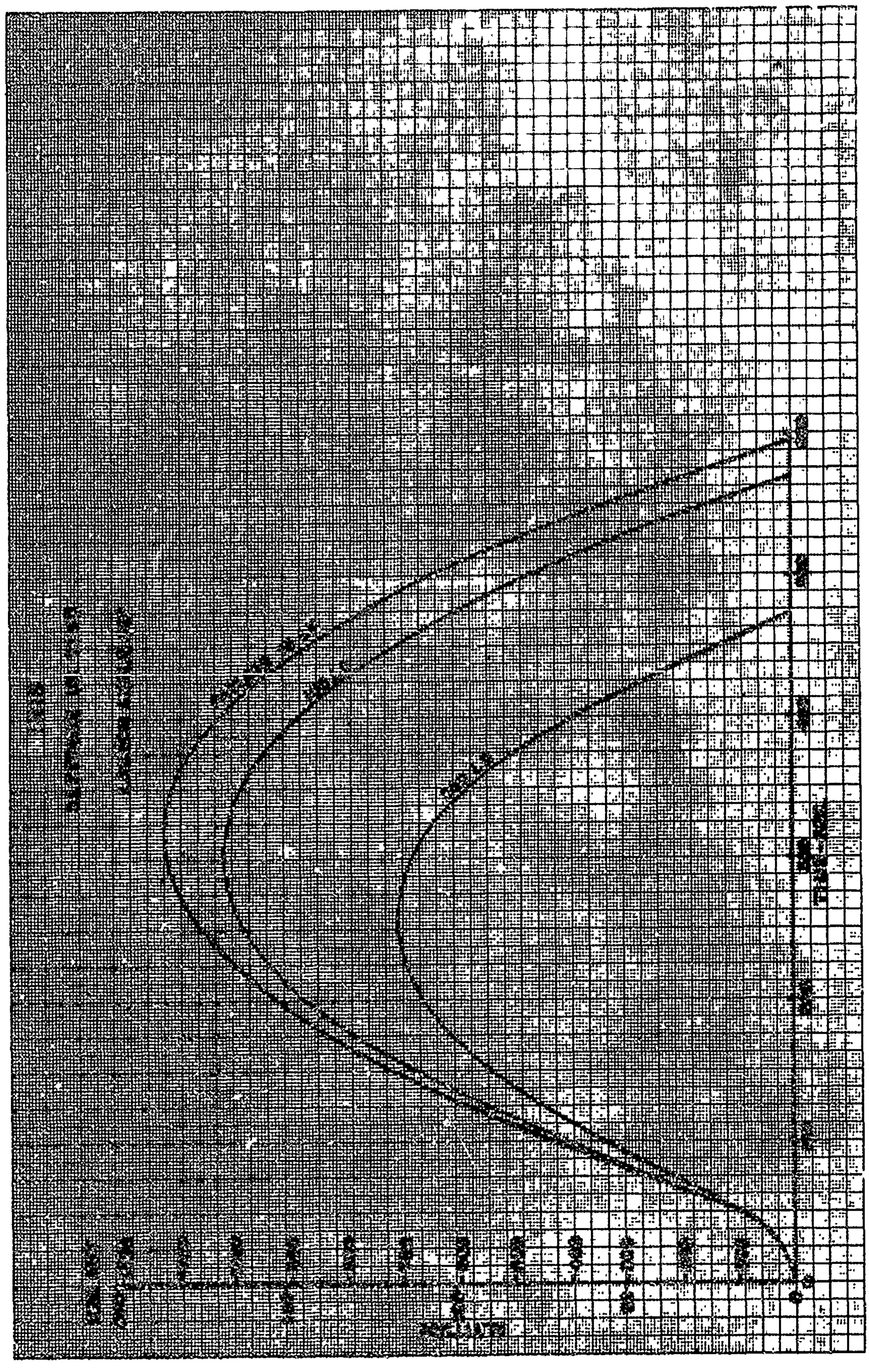
PAYLOAD - COMPARTMENT

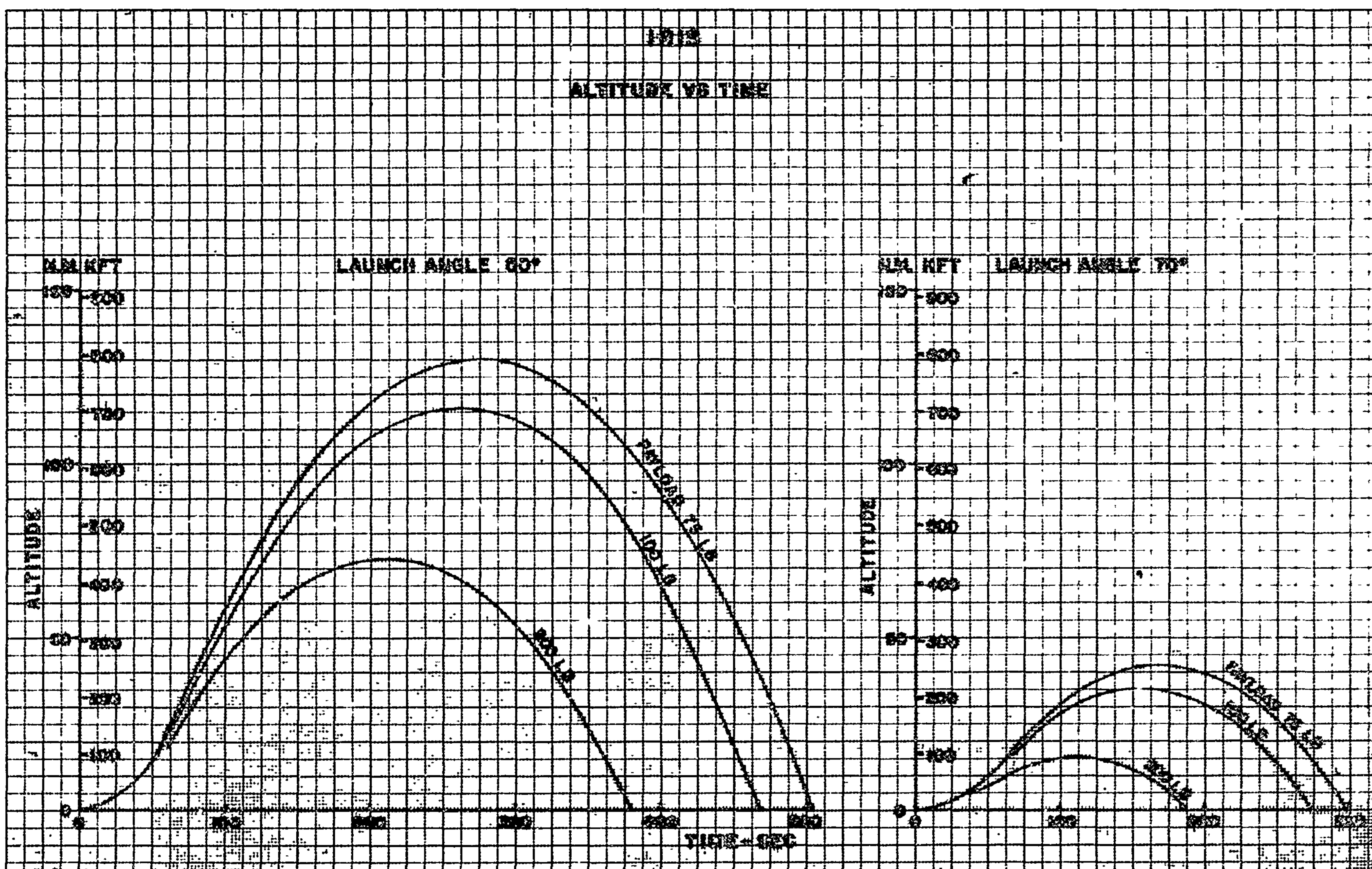


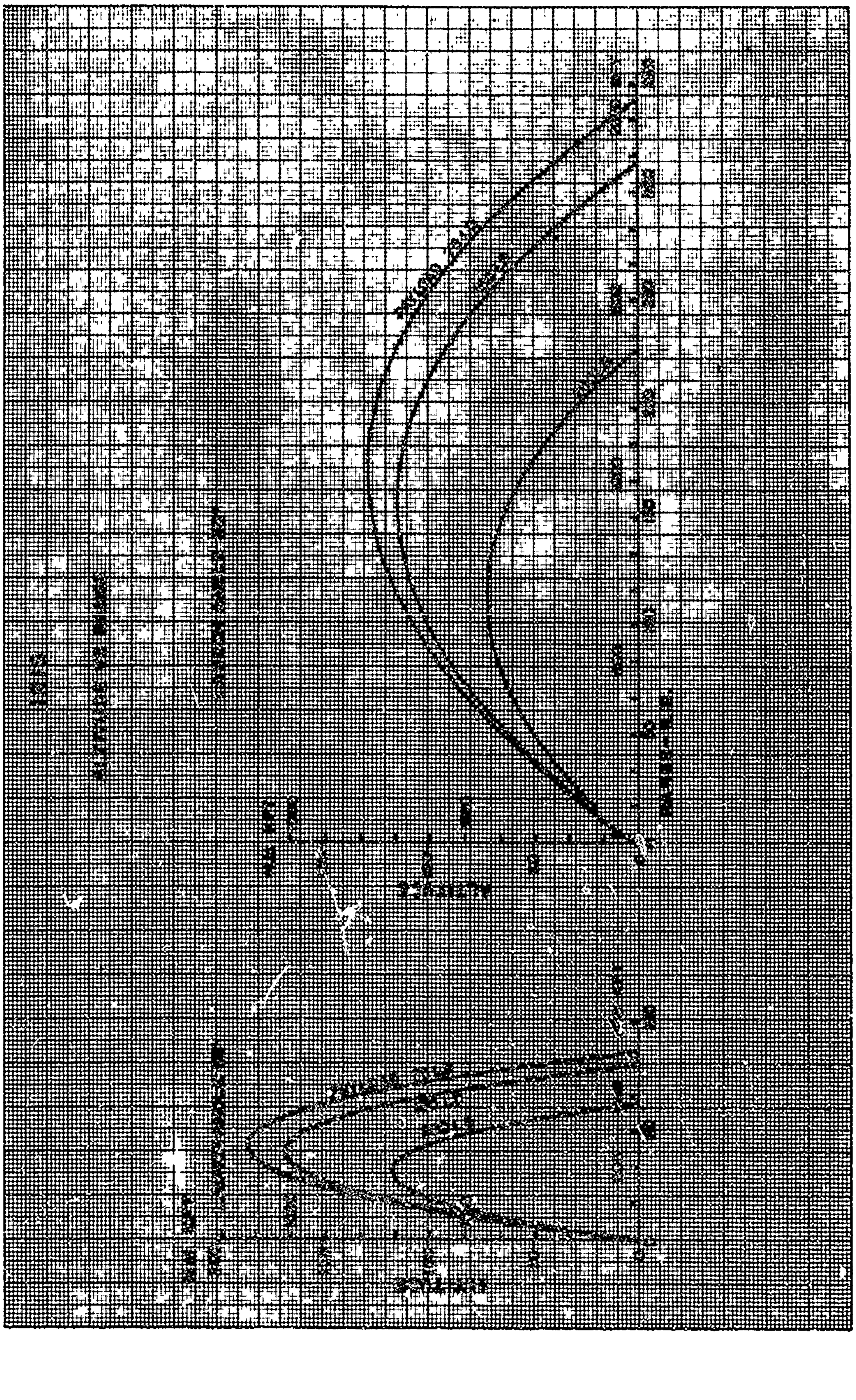


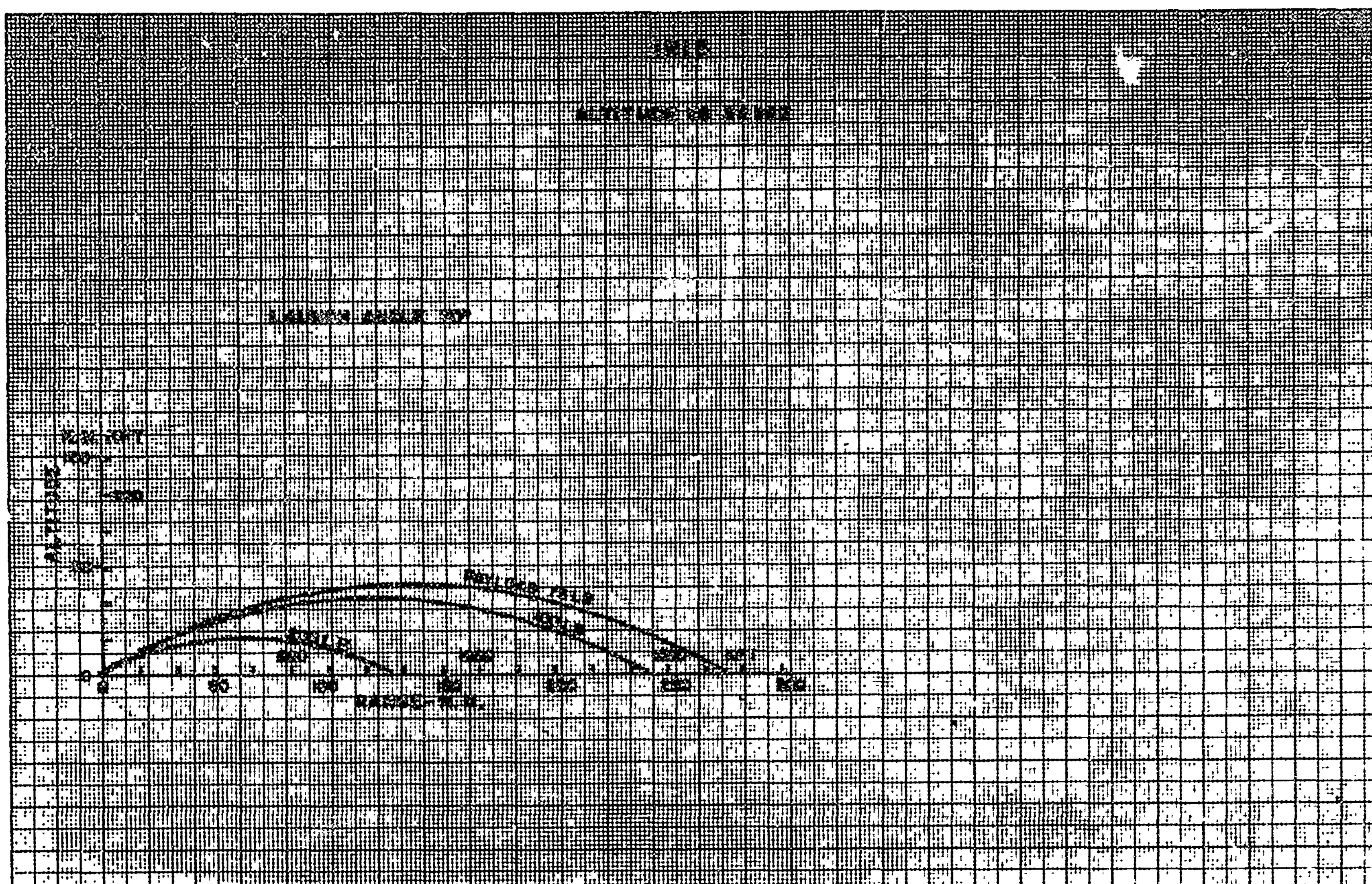
IRIS
ALTITUDE PAYLOAD PERFORMANCE
N.M. KFT
PEAK ALTITUDE
0
50
100
150
200
500
1000
88° LAUNCH ANGLE
80°
70°
50
100
150
200
PAYLOAD

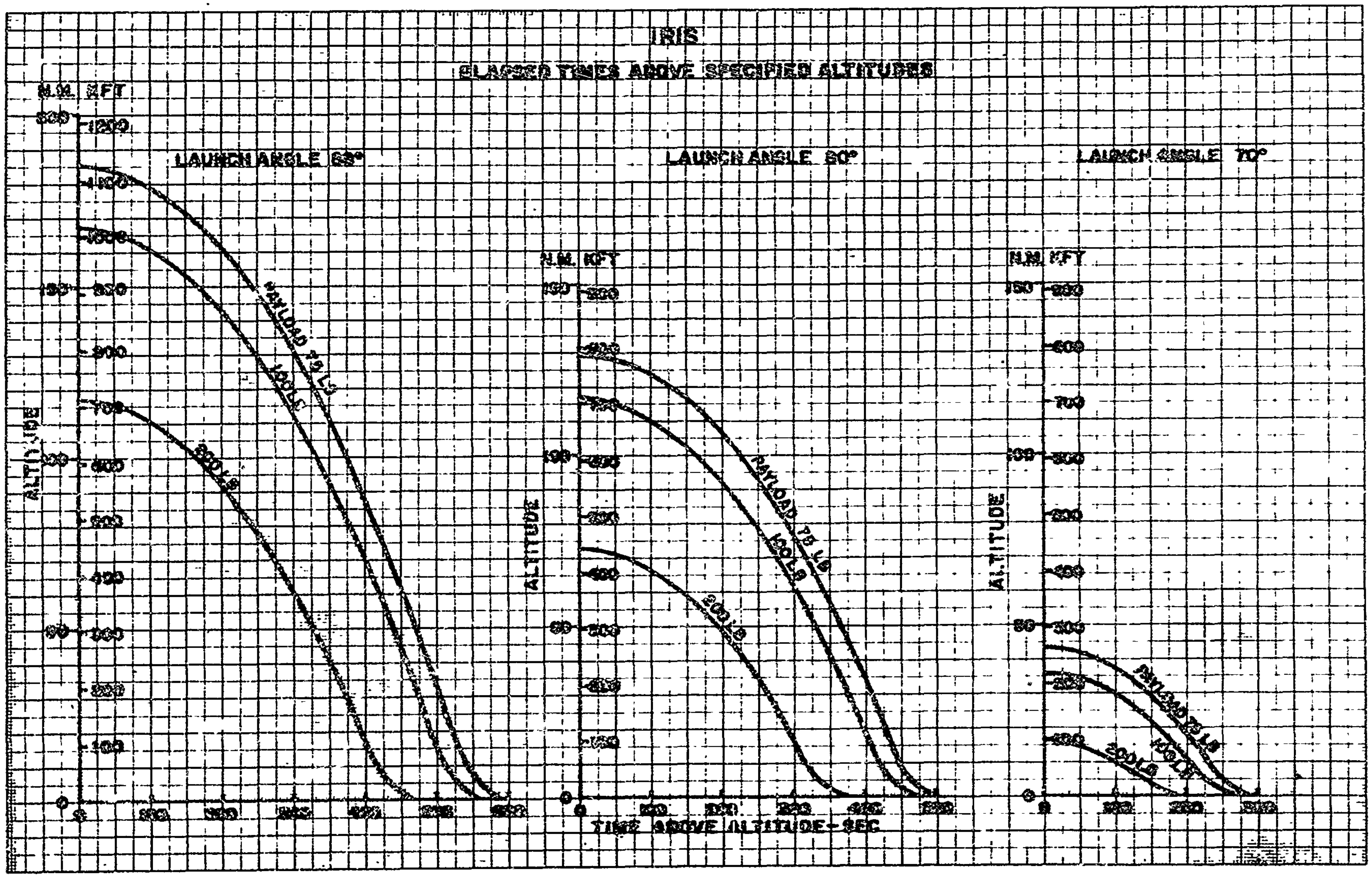

IRIS
PEAK ALTITUDE VS LAUNCH ANGLE
N.M.
KFT
PEAK ALTITUDE
0
50
100
150
200
500
1000
70
80
90
LAUNCH ANGLES - DEGREES




ALTITUDE VS TIME
LAUNCH ANGLE 60°
LAUNCH ANGLE 70°
N.M. KFT
ALTITUDE
TIME - SEC
PAYLOAD 75 LB
100 LB



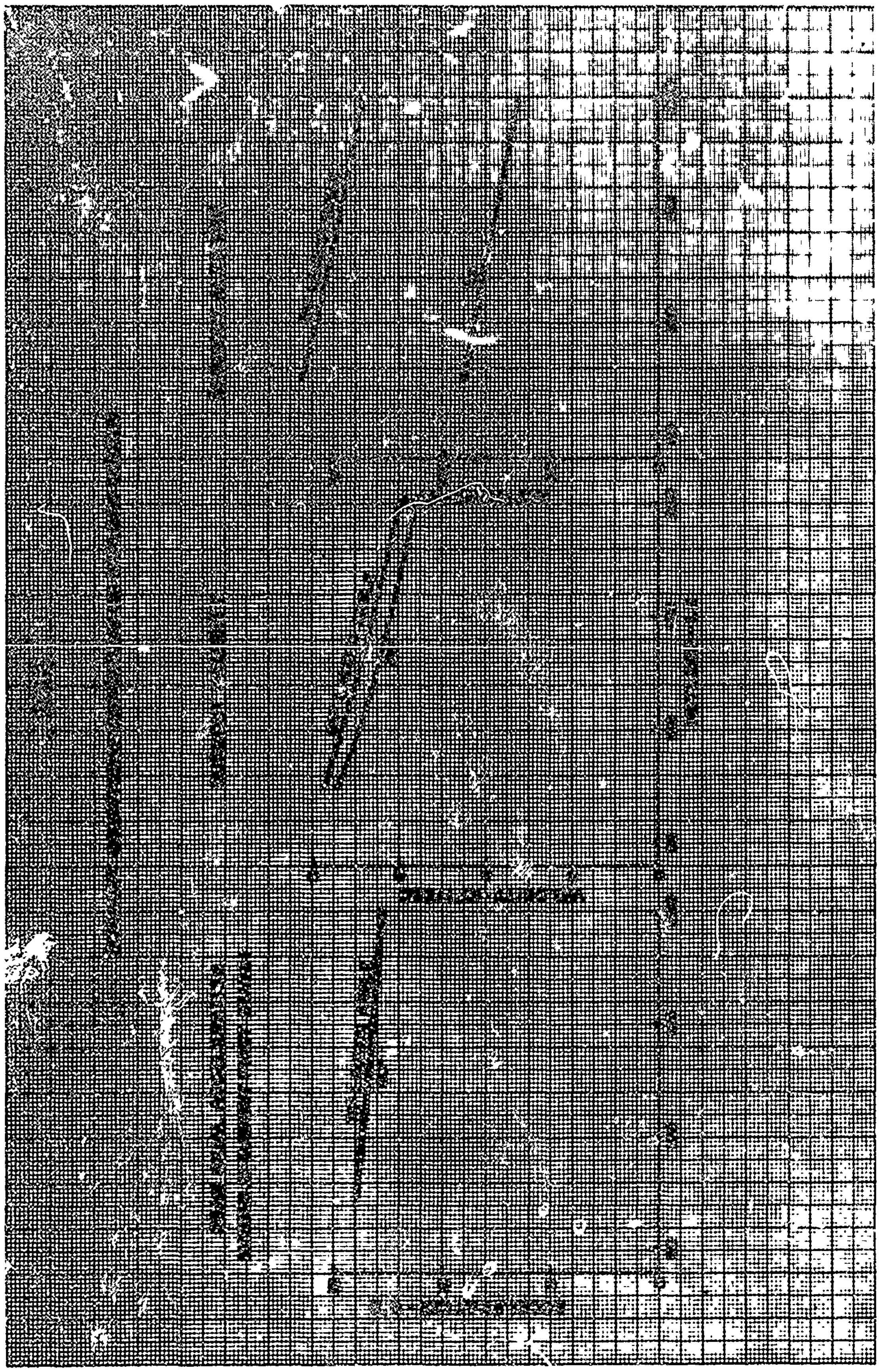

ALTITUDE
0
50
100
RANGE—N.M.



IRIS
ELAPSED TIMES ABOVE SPECIFIED ALTITUDES
LAUNCH ANGLE 80°
PAYLOAD 75 LB
100 LB
200 LB
ALTITUDE
N.M. KFT
TIME ABOVE ALTITUDE - SEC

5-12

78



IRIS

GROUND SUPPORT EQUIPMENT

(1) Launcher

For the launch of an Iris vehicle a launching tower is required. The only launching tower available is the Aerobee tower at Wallops Island, Virginia.

(2) Handling Equipment

There is no information available on existing handling equipment. However, the following equipment will be required: A handling trailer and erector possibly combined, to assemble fins and payload to the booster and to transport the vehicle and to erect it into the tower.

(3) Electrical Support Equipment

To check igniters and time delay relay.

IRIS

AERODYANMIC HEATING
AND
HEATING OF PAYLOAD COMPARTMENT

The aerodynamic heating conditions of the Iris are comparable to the ones encountered at the Aerobee 150. Above 80° launch angle the total aerodynamic heat input is low and heat protection for the nose cone is not necessary. The manufacturer claims that for the most severe trajectory, 200 lb payload and 80° launch angle, the maximum skin temperature of the aluminum nose cone stays between 800° and 900° F. Calculations of Chance-Vought show however that for a 70° trajectory and 100 lb payload the temperature limits for nose tip and leading edges of the fins will be exceeded.

The internal heating of the payload depends on factors like temperature at launch, heat output of payload, outside air temperatures during flight, aerodynamic heat input, sun radiation, heat insulation of payload compartment, absorptivity, emissivity and heat conduction properties of the skin material. It is therefore recommended to check the internal heating for every different payload and launch condition.

JAVELIN

JAVELIN

VEHICLE DESCRIPTION

Name of Vehicle	Javelin, Argo D-4
Manufacturer	Aerolab Development Company Pasadena, California Atlantic Research Corporation Duarte, California
Kind of Vehicle	4 stage, solid propellant, fin stabilized probe vehicle
First Stage Motor	Honest John M6, 4.0-DS-105000 (X202E2) Radford Arsenal
Second Stage Motor	Nike M5, 2.5-DS-59000 (X216A2) Radford Arsenal
Third Stage Motor	Nike M5, 2.5-DS-59000 (X216A2) Radford Arsenal
Fourth Stage Motor	Altair, 38-DS-3100 (X248A6) ABL
Payload Altitude Capability for 88° Launch Angle	75 lb - 609 N.M. 125 lb - 479 N.M. 175 lb - 396 N.M.
Payload Volume	3.5 cu. ft.
Peak Acceleration Peak Deceleration	37.5 G 3.2 G (75 lb payload - 88° L.A.)
Max. Velocity	13050 FPS (75 lb payload - 70° L.A.)
Launch Weight less net payload	7392.4 lb
Reliability	80%
Users	USAF, NASA
Sources	Aerolab, Chance-Vought, NASA, ABL, Hercules Powder Co. Performance Computation: AFMDC Digital Computation Branch

JAVELIN

The Javelin was developed by Aerolab Development Company under NASA sponsorship. This survey considers 25 vehicles launched by NASA and Air Force by the end of 1962.

The manufacturer claims that the vehicle was designed for a net payload range between 50 lb and 100 lb, possibly more. Information received from NASA indicates that the vehicle has been flown with net payloads as low as 37 lb and as high as 159 lb. Chance-Vought Report AST/EIR-13 326 shows an estimated net payload range between 75 lb and 175 lb. The performance calculation in this report uses the Chance-Vought payload range because the information of Aerolab and NASA had not yet been received at the time when the calculations were performed.

A comparison of calculated performances by ORA with NASA nominal performance data and Aerolab advertised performances show good agreement for a launch angle of 80°. (See graph on page 6-16.) Also some of the predicted values of NASA firings agree reasonably well with ORA calculations. The Chance-Vought curve appears too optimistic. The difference,however, between predicted and observed altitudes in the lower payload range is rather large and suggests malfunction of motors or poor attitude of the vehicle. In two firings, the Altair motor did not develop the full burning period. The spread of the observed altitudes is such that a 75° launch angle curve would represent realistic payload-altitude performances when the vehicle is launched at an 80° angle. (See page 6-16.)

The firing sequence of the Javelin vehicle is as follows: The first stage motor burns for about 4 seconds. At burnout it separates by drag and the vehicle consisting of second, third and fourth stages coasts for 5 seconds. Here the second stage is ignited and burns for about 3.5 seconds, separated by drag at burnout. A 12-second coast period of third and fourth stages follows after which the third stage is fired. Burning time of the third stage is 3.5 seconds. After burnout the third stage stays attached to the fourth and both stages coast for a period of 21 seconds, to provide adequate gyroscopic stabilization. At the end of this coasting period fourth stage ignition occurs

and the empty third stage separates by means of a NASA blow-out diaphragm. Two seconds later heat shield and support tube of the fourth stage are dropped. Burning time of the fourth stage is about 40 seconds. The total time of the burning phase, including coasting, amounts to about 90 seconds.

In the basic configuration, nose cone and expended fourth stage stay coupled together, however, a separation device is offered as an option. The separation time can be preset from 120 to 180 seconds.

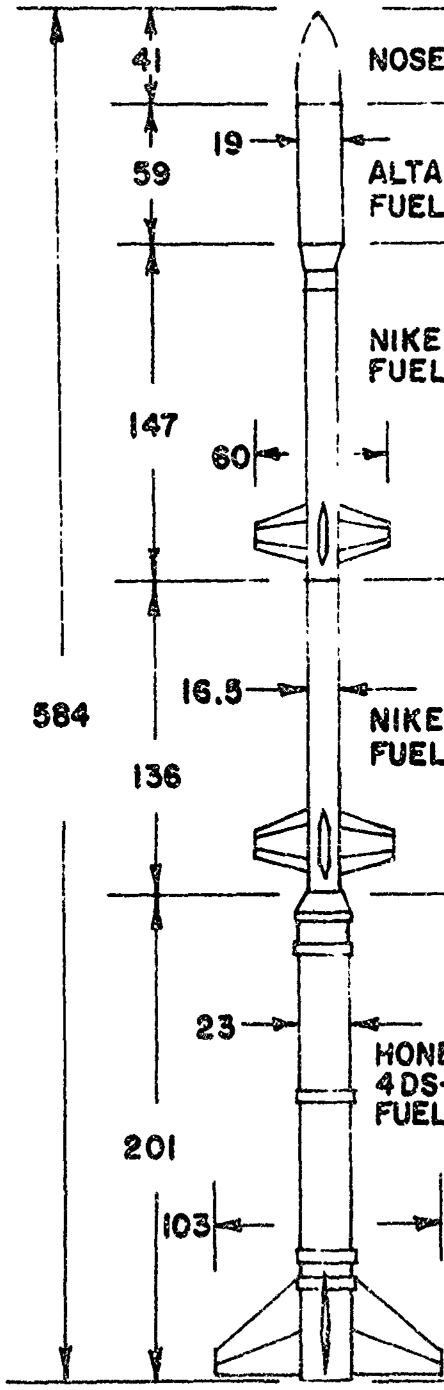
The first 3 stages of the vehicle are stabilized by cruciform fins. The fourth stage is spin stabilized, the spin rate being induced by the fins of the lower stages. The fins are field adjustable so that the roll program can be varied within the stability limits of the vehicle. A typical roll program for the Javelin is approximately one, six, eleven and ten revolutions per second during burning of the first, second, third and fourth stage, respectively. In the case of nose cone ejection, the roll rate of the nose cone can be reduced to any smaller value desired for the experiment, including zero.

Vibration data from NRL discussed in Chance-Vought Report AST/EIR-13 326 indicate that the maximum vibration level measured on the payload baseplate occurs during burning of the fourth stage. The vibration was of high frequency and quasi-sinusoidal, the maximum being 30 G rms. A quasi-sinusoidal vibration mode of 600 cps and high energy but short duration, observed during more than half of the static firings and flights of the X-248 motor, did not appear during the firings discussed in the Chance-Vought report. However, if the absence of this mode is only statistical, chances are that it will occur during a number of flights.

JAVELIN

ASSEMBLY, DIMENSIONS AND WEIGHTS

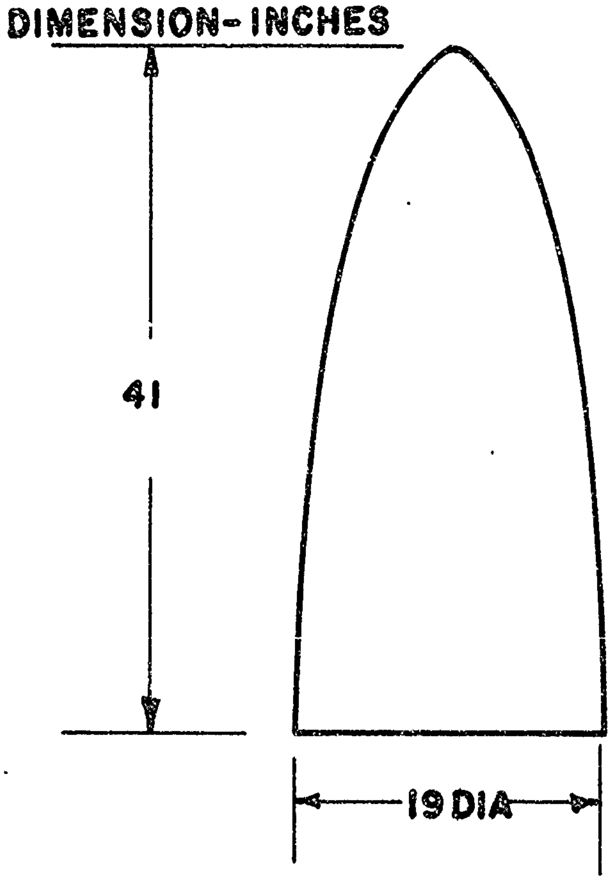
PAYLOAD 75 - 175 LB.



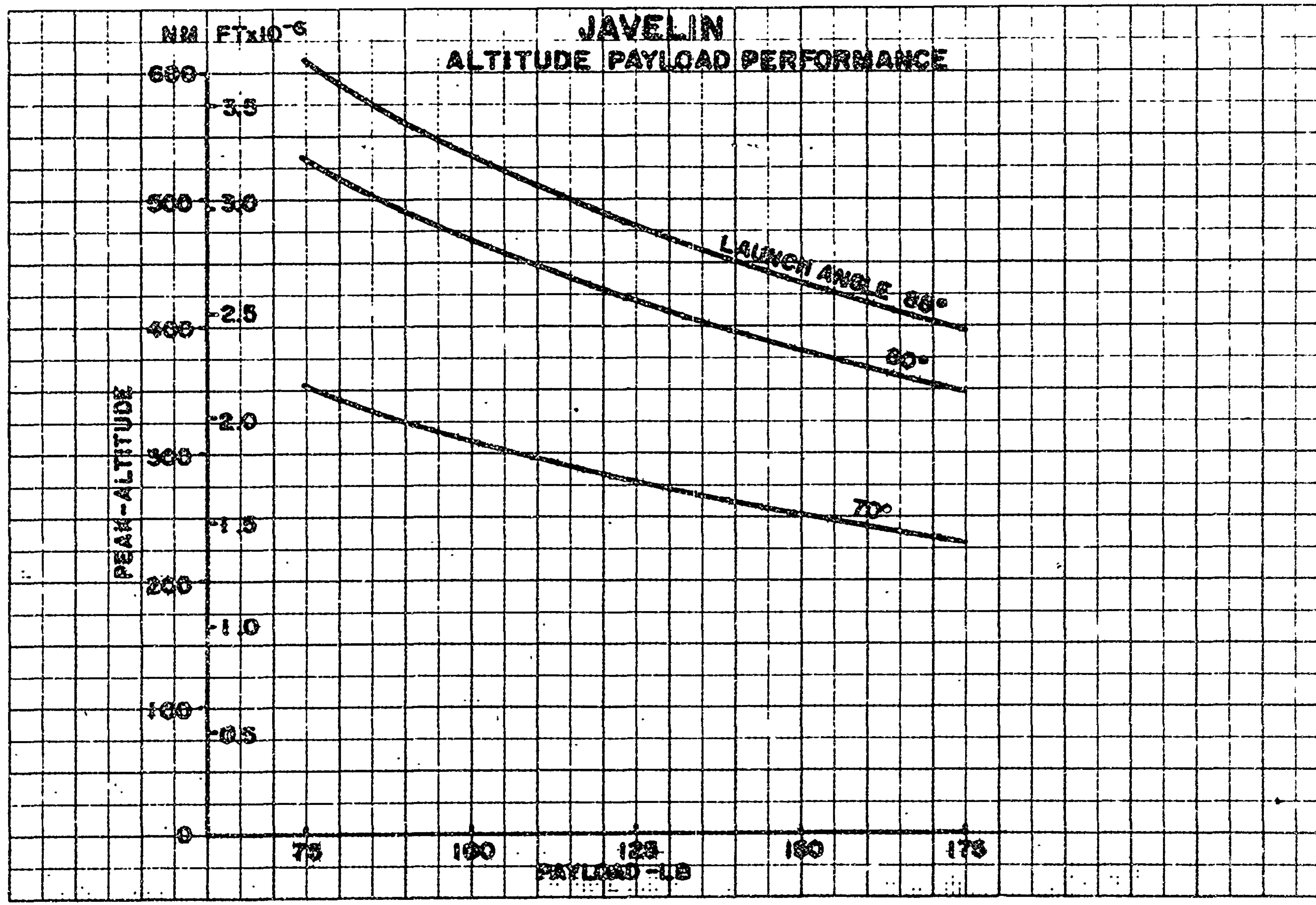
	WEIGHT LB.	PROPELLANT CONSUMED LB.
NOSE CONE	30	
ALTAIR, X248-A6 FUELED	554.3	464
NIKE M5, 2.5DS-59,000 FUELED	1323.4	764
NIKE M5, 2.5DS-59,000 FUELED	1313.2	764
HONEST JOHN, 4DS-105,000 FUELED	4171.5	2180.0
LAUNCH WEIGHT	7392.4	

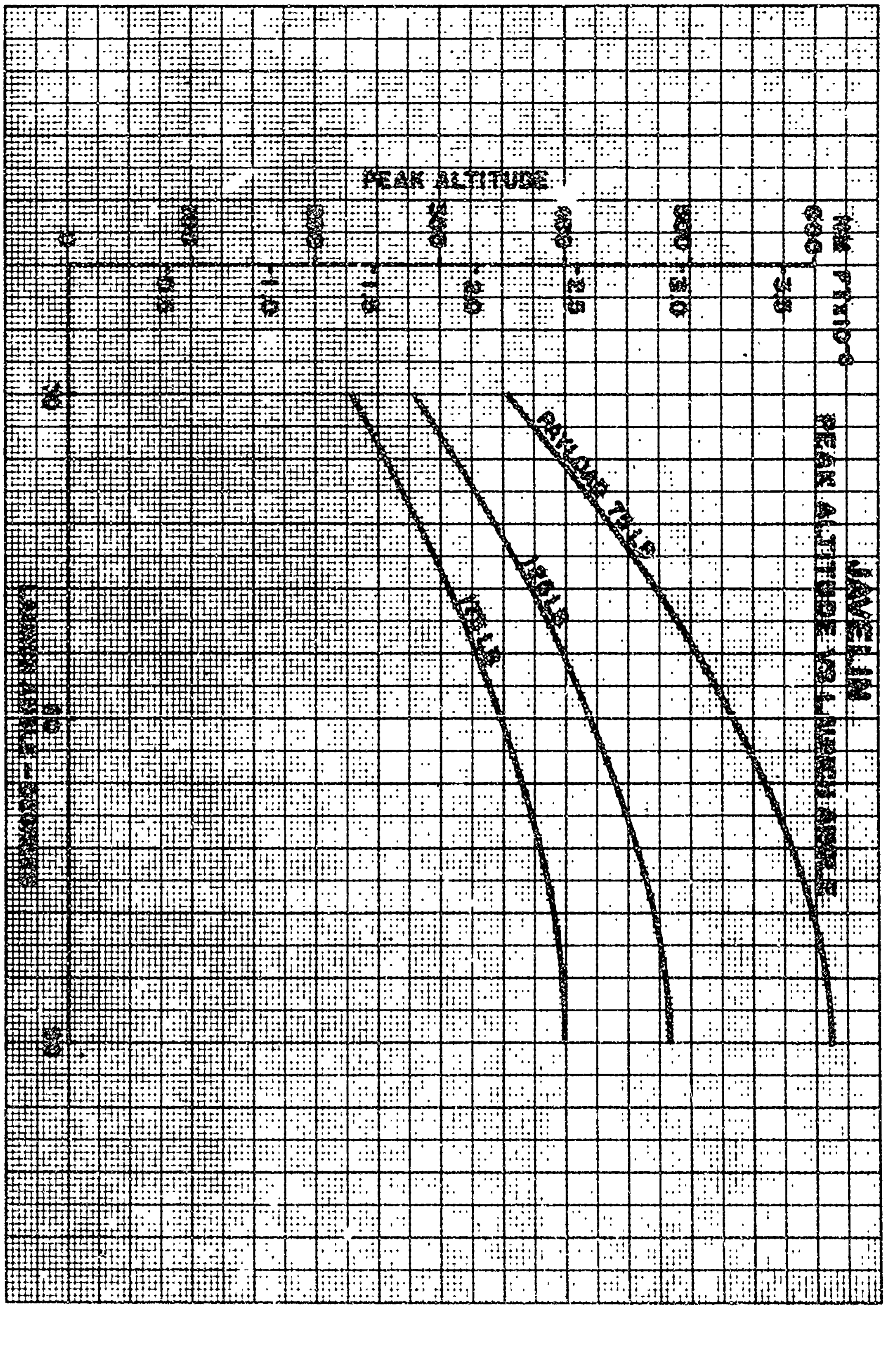
JAVELIN

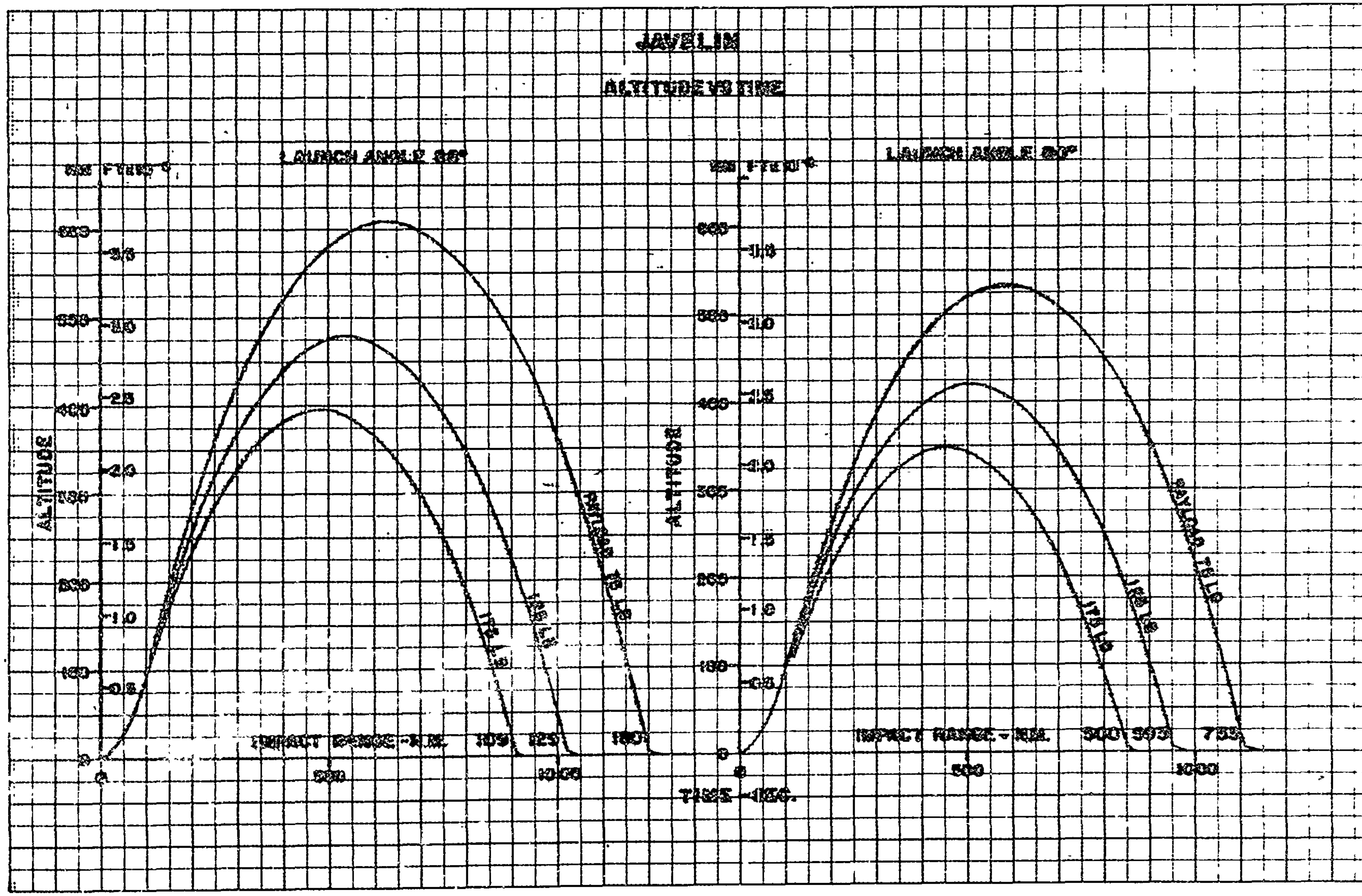
PAYLOAD COMPARTMENT

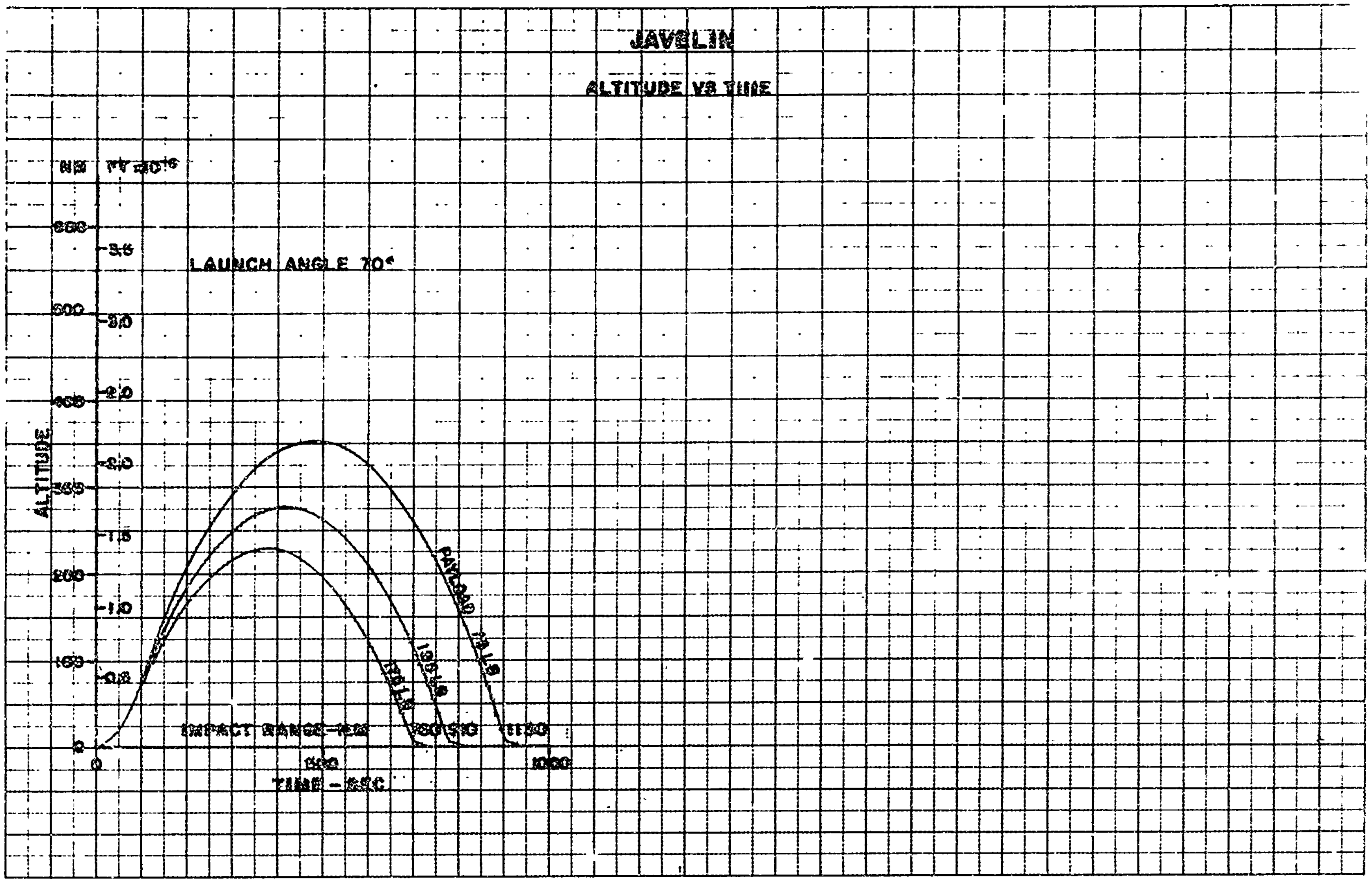


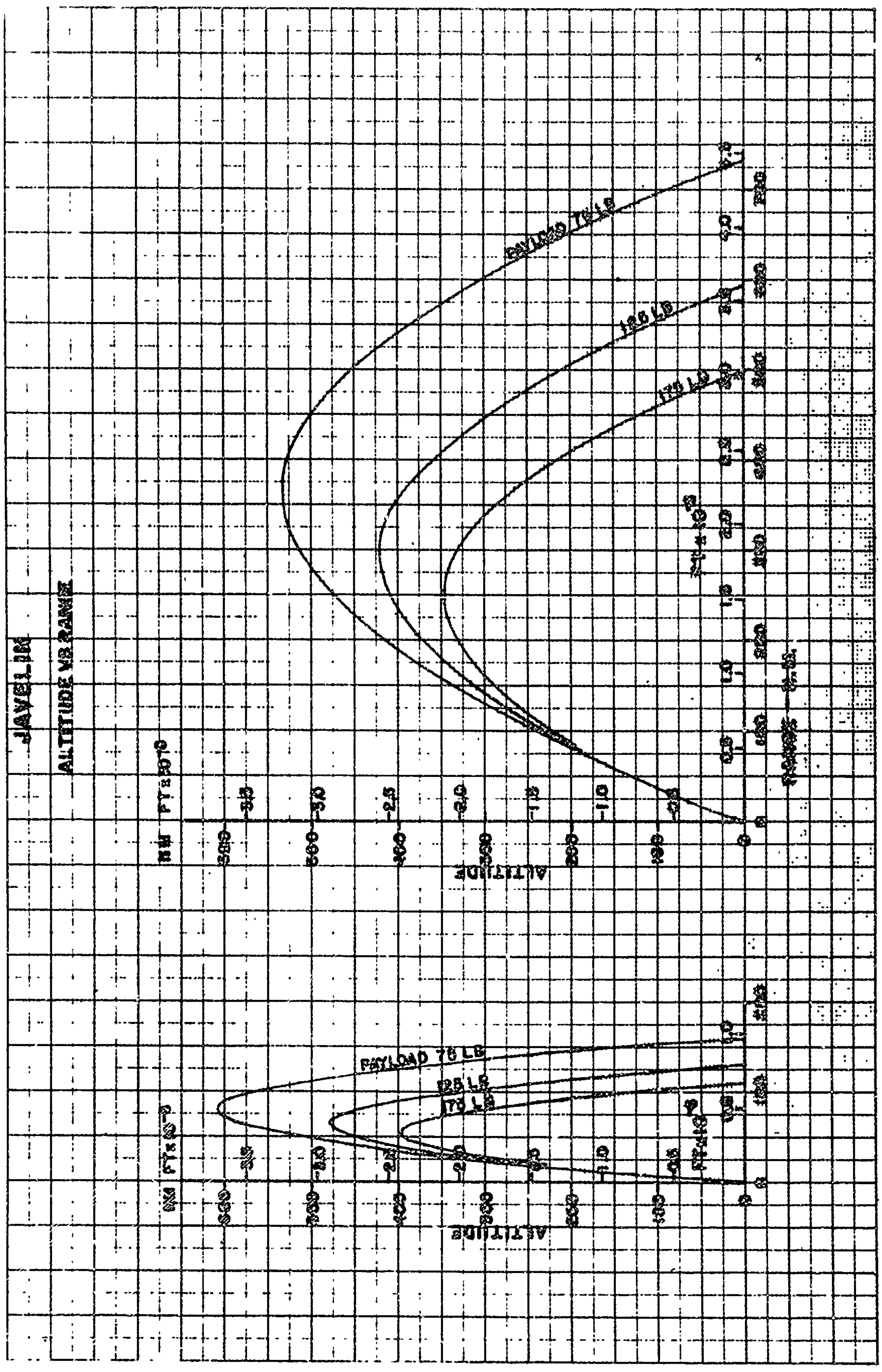
MAXIMUM VOLUME 3.5 CU. FT.

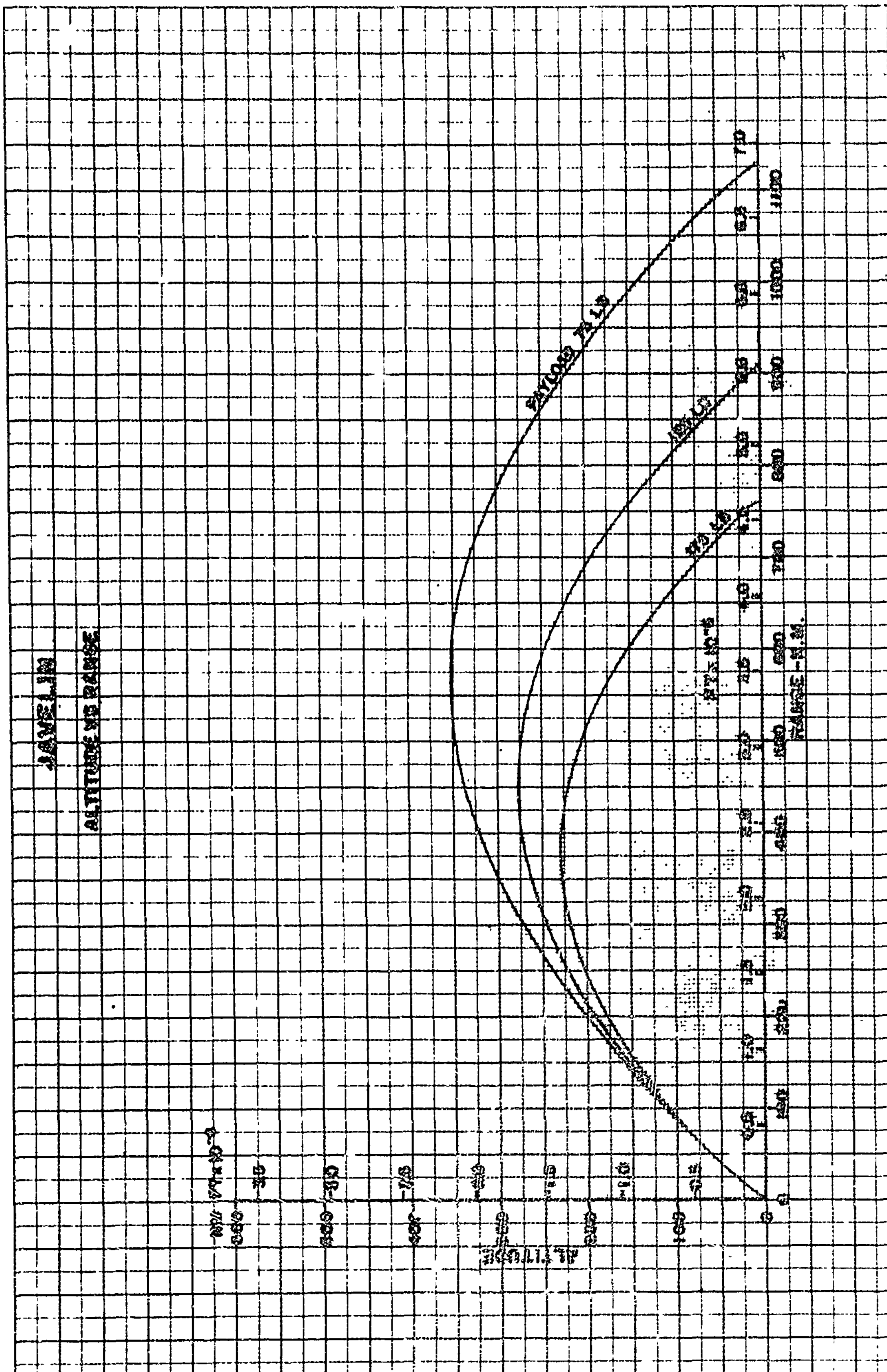

JAVELIN
ALTITUDE PAYLOAD PERFORMANCE
NM
FTx10^-6
600
500
400
300
200
100
0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
PEAK-ALTITUDE
LAUNCH ANGLE 86°
80°
70°
75
100
125
150
175
PAYLOAD-LB

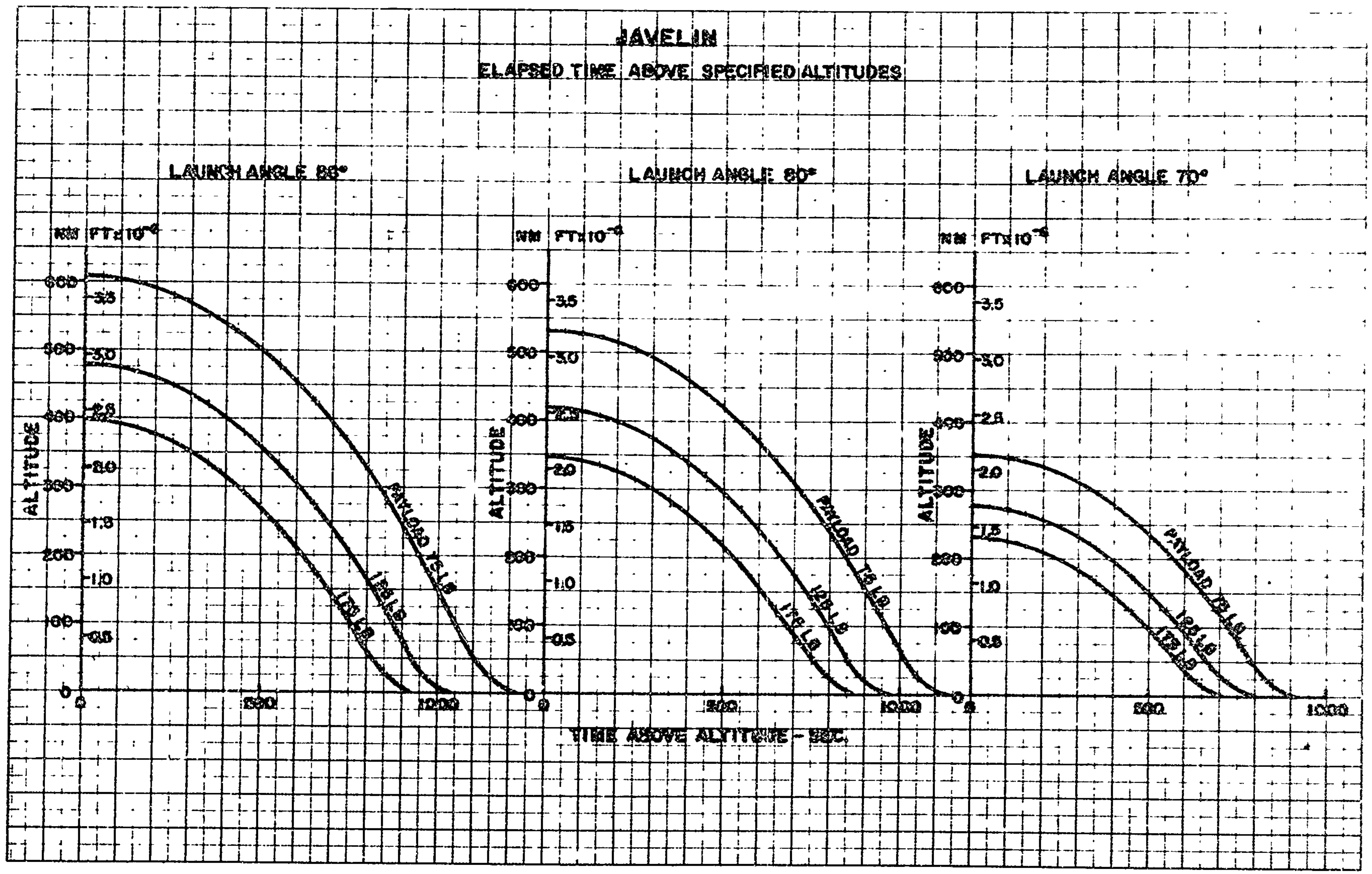

JAVELIN
PEAK ALTITUDE VS LAUNCH ANGLE
PEAK ALTITUDE
KM
600
500
400
300
200
100
0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
PAYLOAD 79 LB
126 LB
175 LB
30
60
90
LAUNCH ANGLE – DEGREES

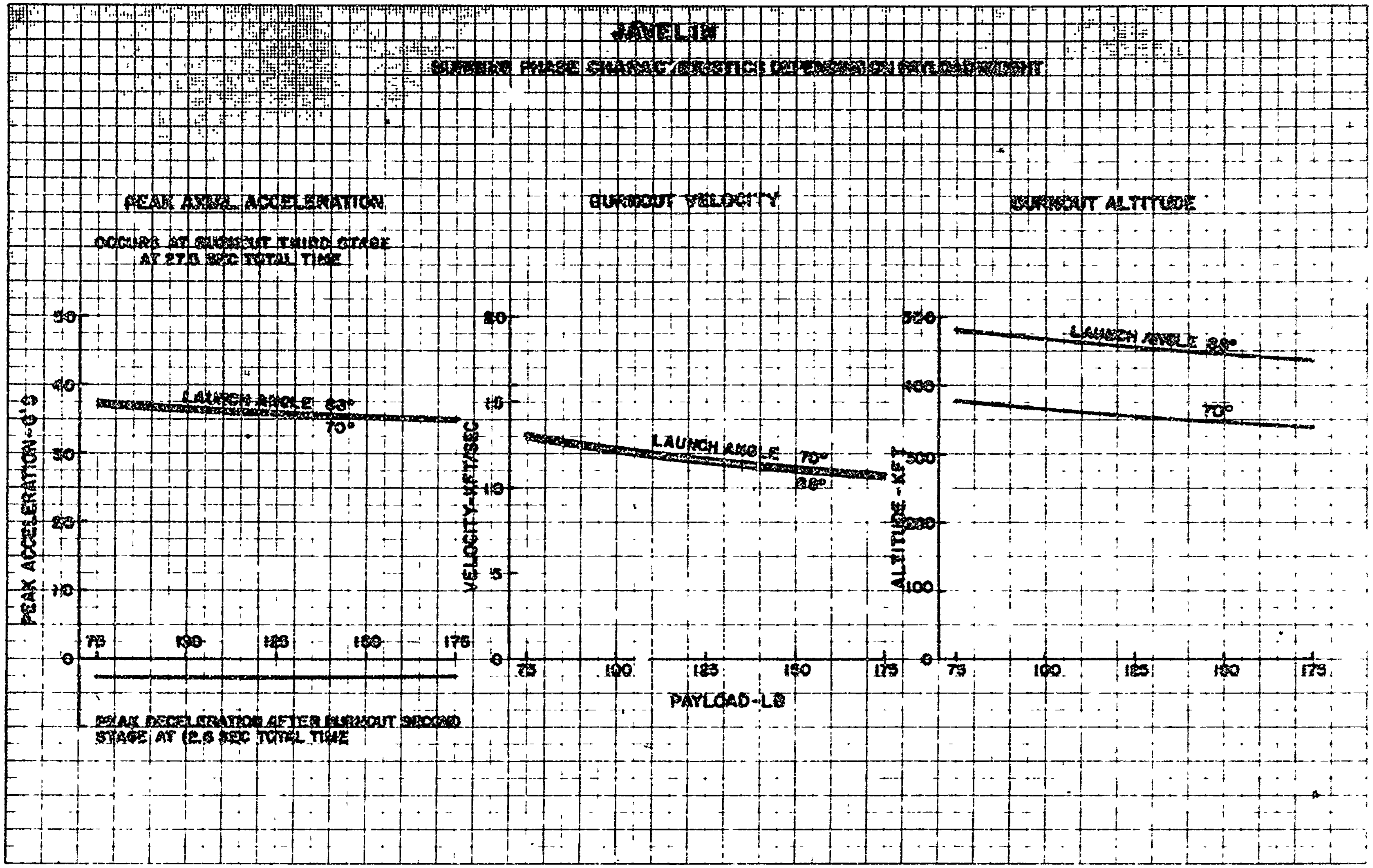

JAVELIN
ALTITUDE VS TIME
ALTITUDE
IMPACT RANGE - N.M.
TIME - SEC.
500
1000

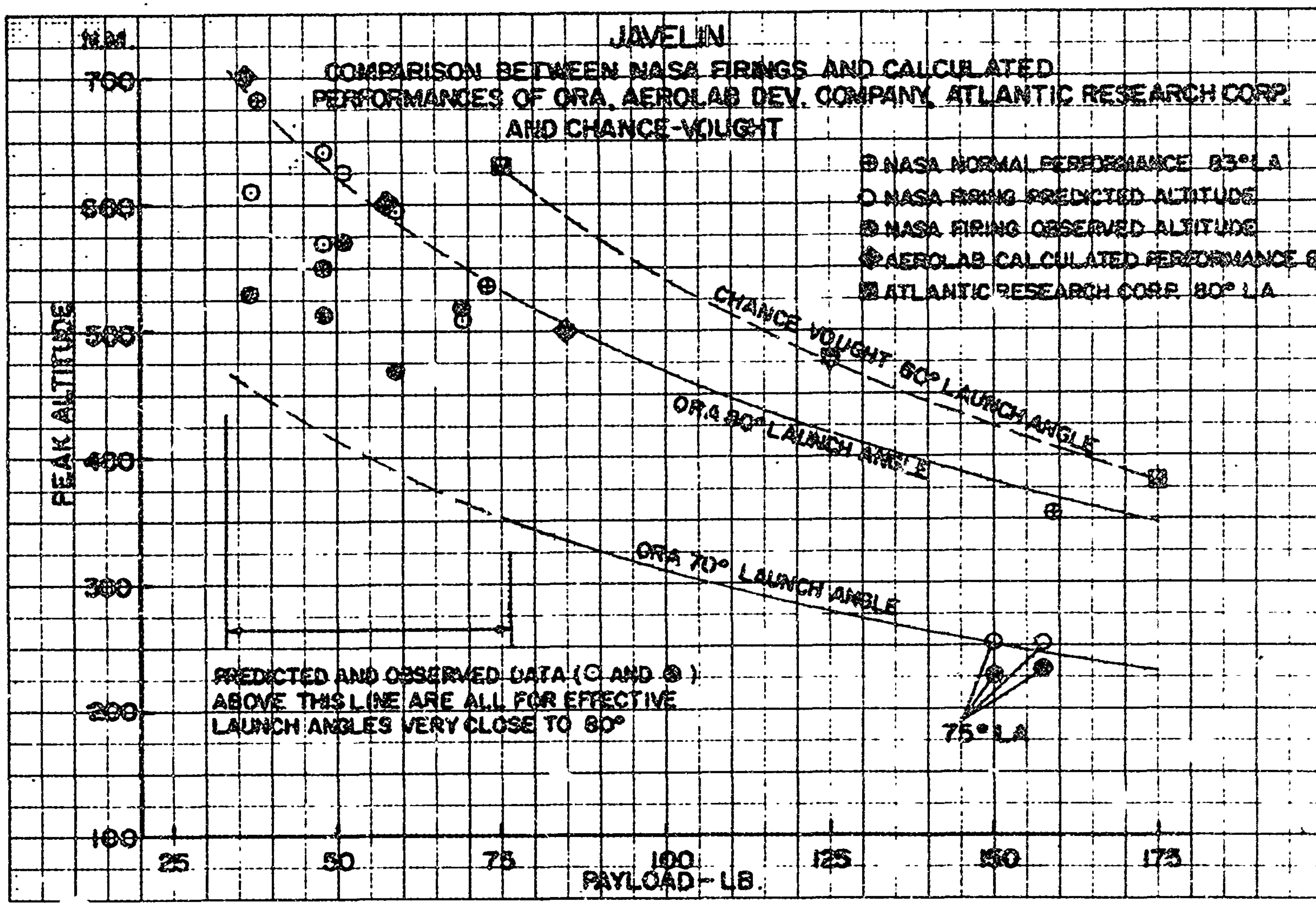

JAVELIN
ALTITUDE VS TIME
LAUNCH ANGLE 70°
ALTITUDE
TIME - SEC
0
500
1000


JAVELIN
ALTITUDE VS RANGE
PAYLOAD 75 LB
125 LB
170 LB
ALTITUDE
RANGE


JAVELIN
ALTITUDE VS RANGE
ALTITUDE
RANGE-N.M.


JAVELIN
ELAPSED TIME ABOVE SPECIFIED ALTITUDES
LAUNCH ANGLE 80°
LAUNCH ANGLE 70°
NM
FT x 10⁻⁶
ALTITUDE
PAYLOAD
TIME ABOVE ALTITUDE - SEC.


JAVELIN
PEAK AXIAL ACCELERATION
OCCURS AT BURNOUT THIRD STAGE
AT 27.0 SEC TOTAL TIME
PEAK ACCELERATION-G'S
LAUNCH ANGLE 83°
70°
PEAK DECELERATION AFTER BURNOUT SECOND
STAGE AT 12.6 SEC TOTAL TIME
BURNOUT VELOCITY
VELOCITY-KFT/SEC
LAUNCH ANGLE 70°
83°
BURNOUT ALTITUDE
ALTITUDE-KFT
LAUNCH ANGLE 83°
70°
PAYLOAD-LB


JAVELIN
COMPARISON BETWEEN NASA FIRINGS AND CALCULATED PERFORMANCES OF ORA, AEROLAB DEV. COMPANY, ATLANTIC RESEARCH CORP. AND CHANCE-VOUGHT
NASA NORMAL PERFORMANCE 83° L.A.
NASA FIRING PREDICTED ALTITUDE
NASA FIRING OBSERVED ALTITUDE
AEROLAB CALCULATED PERFORMANCE 80° L.A.
ATLANTIC RESEARCH CORP. 80° L.A.
CHANCE-VOUGHT 80° LAUNCH ANGLE
ORA 80° LAUNCH ANGLE
ORA 70° LAUNCH ANGLE
PREDICTED AND OBSERVED DATA (○ AND ⊗) ABOVE THIS LINE ARE ALL FOR EFFECTIVE LAUNCH ANGLES VERY CLOSE TO 80°
75° L.A.
PEAK ALTITUDE
N.M.
PAYLOAD – LB.

JAVELIN

HARDWARE IMPACT RANGES

88° LAUNCH ANGLE

All stages impact within 20 N. M. range for payloads between 75 lbs and 175 lbs

80° LAUNCH ANGLE

Payload Lb	First Stage N. M.	Second Stage N. M.	Third Stage N. M.
75	5.9	10.6	83.3
125	4.7	10.4	79.8
175	4.6	10.3	76.6

70° LAUNCH ANGLE

Payload Lb	First Stage N. M.	Second Stage N. M.	Third Stage N. M.
75	8.1	15.2	135.4
125	8.0	15.0	129.7
175	7.9	14.8	124.4

JAVELIN

GROUND SUPPORT EQUIPMENT

For the assembly, checkout, and launch of the Javelin the following equipment and facilities are required:

(1) Launcher

The Javelin can be launched from a zero length, boom type launcher. In Wallops Island, Virginia, a modified Sergeant launcher is used. The Fort Churchill range in Manitoba, Canada, uses a newly installed Aerolab launcher. This launcher is remotely controlled and monitored from the blockhouse and provides better positioning stability in high winds. Adapter hardware available enables the launcher to be used with Nike-Cajun, Nike-Apache, Black Brant and Honest John-Nike-Nike vehicles. The same type Aerolab launcher is installed at White Sands Missile Range.

(2) Handling Equipment

The handling equipment consists of:

- Holding fixtures
- Motor slings
- Work stands
- Motor storage facility
- Three air log dollies and adapter assemblies
- Assembly tools for fin setting
- One fork lift truck

(3) Electrical Support Equipment to check igniter-circuity, firing squibs and timers.

JAVELIN

AERODYNAMIC HEATING AND HEATING OF PAYLOAD COMPARTMENT

Two payload compartments of the same ogival contour but different materials are offered. One, manufactured from fiberglass, has a spray coated ablative sheath and consists of two envelopes separated by foam insulation. The second nose cone type has an Inconel outer form and a fiberglass inner envelope. The space in between again is filled with foam insulation.

The aerodynamic heating is not critical. The aerodynamic heat input in the fiberglass cone with the ablative heat shield is only 54 Btu according to information received from the manufacturer and NASA. The aerodynamic heat transfer into the Inconel cone is claimed to be not higher than 192 Btu.

The maximum volume of the nose cones is listed to be 3.5 cu ft. Extensions are offered but no information was available on their maximum length and volume.

The internal heating of the payload depends on factors like temperature at launch, heat output of payload, outside air temperatures during flight, aerodynamic heat input, sun radiation, heat insulation of payload compartment, absorptivity, emissivity and heat conduction properties of the skin material. It is therefore recommended to check the internal heating for every different payload and launch condition.

EXOS

EXOS

VEHICLE DESCRIPTION

Name of Vehicle	EXOS
Designer	University of Michigan
Manufacturer	No specific manufacturer. Purchase of components and system integration by AFCRL.
Kind of Vehicle	3 stage, solid propellant, fin stabilized probe vehicle
First Stage Motor	Honest John M6, 4.0-DS-105000 (X202E2) Radford Arsenal
Second Stage Motor	Nike M5 2.5-DS-59000 (X216A2) Radford Arsenal
Third Stage Motor	Yardbird, 4.6-KS-14700 (TE-289-1) Thiokol Chemical Corporation, Elkton Md Division
Payload-Altitude Capability for 80° Launch Angle	40 lb - 346 N.M. 60 lb - 312 N.M. 130 lb - 235 N.M.
Payload Volume	1.0 cu. ft.
Peak Acceleration	80 G's (40 lb payload - 88° L.A.)
Peak Deceleration	1.9 G's (40 lb payload - 80° L.A.)
Max. Velocity	11580 FPS (40 lb payload - 88° L.A.)
Launch Weight less net payload	5880.2 lb
Reliability	5 successes out of 7 firings
User	USAF(AFCRL)
Sources	University of Michigan, Chance Vought, AFCRL, ABL, Hercules Powder Co., Thiokol. Performance Computation: AFMDC Analog Computation Division.

EXOS

The EXOS sounding rocket was designed by the University of Michigan in 1958 under sponsorship of AFCRL with the cooperation of NASA to carry a 40 lb payload to the 300 N. M. altitude level. It is about the only vehicle in existance which fulfills this requirement economically. The first two vehicles were equipped with a Thiokol RECRUIT motor as the third stage. However the very high longitudinal acceleration of approximately 175 G's at burnout was restrictive for many payloads. The RECRUIT motor was replaced by the longer burning YARDBIRD motor of about the same total impulse, reducing the maximum acceleration to a safer 80 G level.

The fi. t stage uses standard HONEST JOHN fins, while the second stage (NIKE) is fitted with 2.5 ft^2 smaller than standard fins. (Standard NIKE fins would be too large and too weak for the second stage application.) The third stage has a flared skirt for stabilization which is effective in preventing flat spins. A roll rate can be imparted by variable incidence fins of the first two stages.

The flight test experiences of AFCRL obtained in seven firings are the following: The attitude stability of the vehicle is considered fair. AFCRL recommends a roll rate of 6 rps for the stabilization of the third stage, rather than spin rates of 1/2 to 2 rps, originally applied which allowed generation of high attack angles due to thrust misalignment moments at third stage ignition. Vibration measurements show that the NIKE motor induces during ignition 10 G's RMS lateral and 20 G's RMS longitudinal random vibrations at about 20 cps in the payload. HONEST JOHN and YARDBIRD motors represent no vibration problem.

Transport, assembly and checkout characteristics of the EXOS are satisfactory. Normal storage precautions are adequate. The time required to prepare a rocket for flight is about 3 man-weeks (excluding payload).

The EXOS is insensitive to small external modifications of the nose cone. No payload recovery system is available.

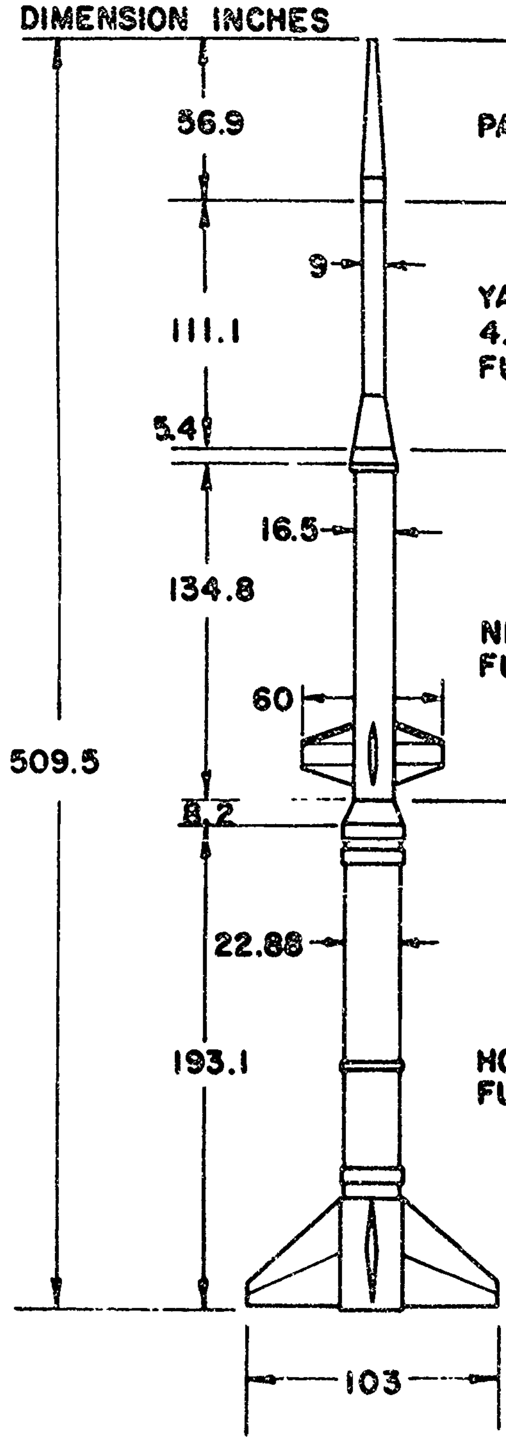
The firing sequence is as follows: The first stage burns for 4.5 seconds and separates at burnout by means of a slip fit coupling and differential drag. A 25 second coast period follows after which the second stage ignites by timer and batteries. The second stage burns for 3.5 seconds. The pressure drop at burnout signals third stage ignition. Separation of second and third stage is achieved by a NASA blow-out diaphram. The burning time of the third stage is 4.7 seconds. The total time from first stage ignition to burnout third stage, including coasting, is 37.7 seconds.

In the performance graph (Page 7-14) the calculated performances agree reasonably well with the actually flown performances. The AFCRL expected performance curve will produce realistic values. The good agreement of predicted and observed altitudes in five firings is remarkable. The calculations were made for a payload range of 40 lbs to 100 lbs, however net payload weights up to 130 lbs have been flown as can be seen on the graph.

EXOS

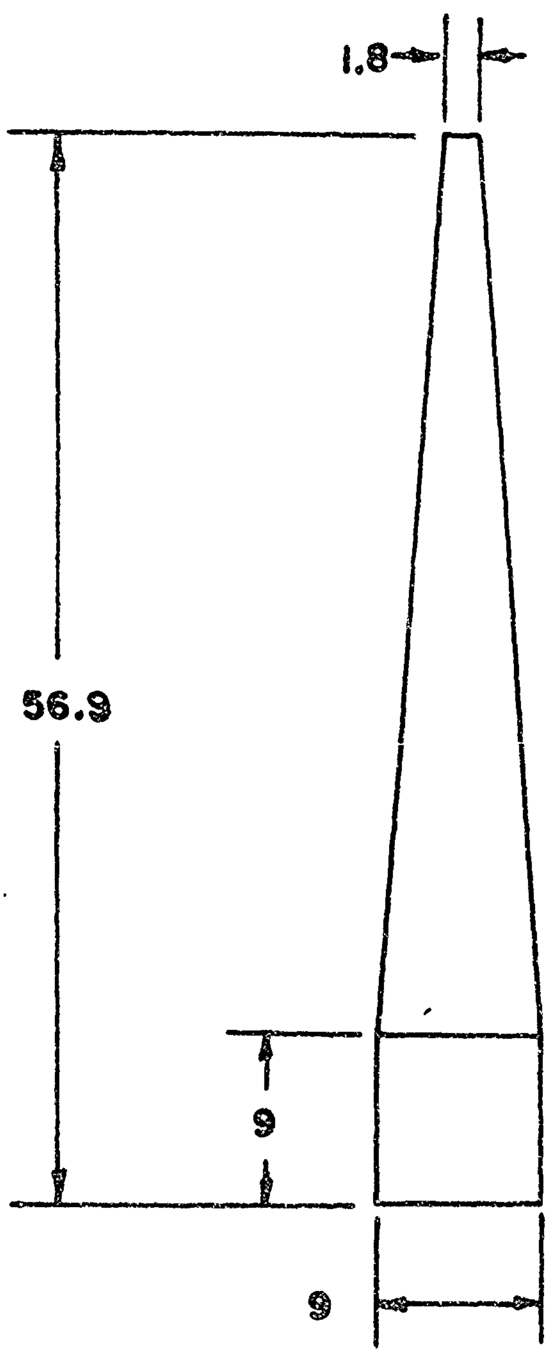
ASSEMBLY, DIMENSIONS AND WEIGHTS

PAYLOAD 40-130 LB

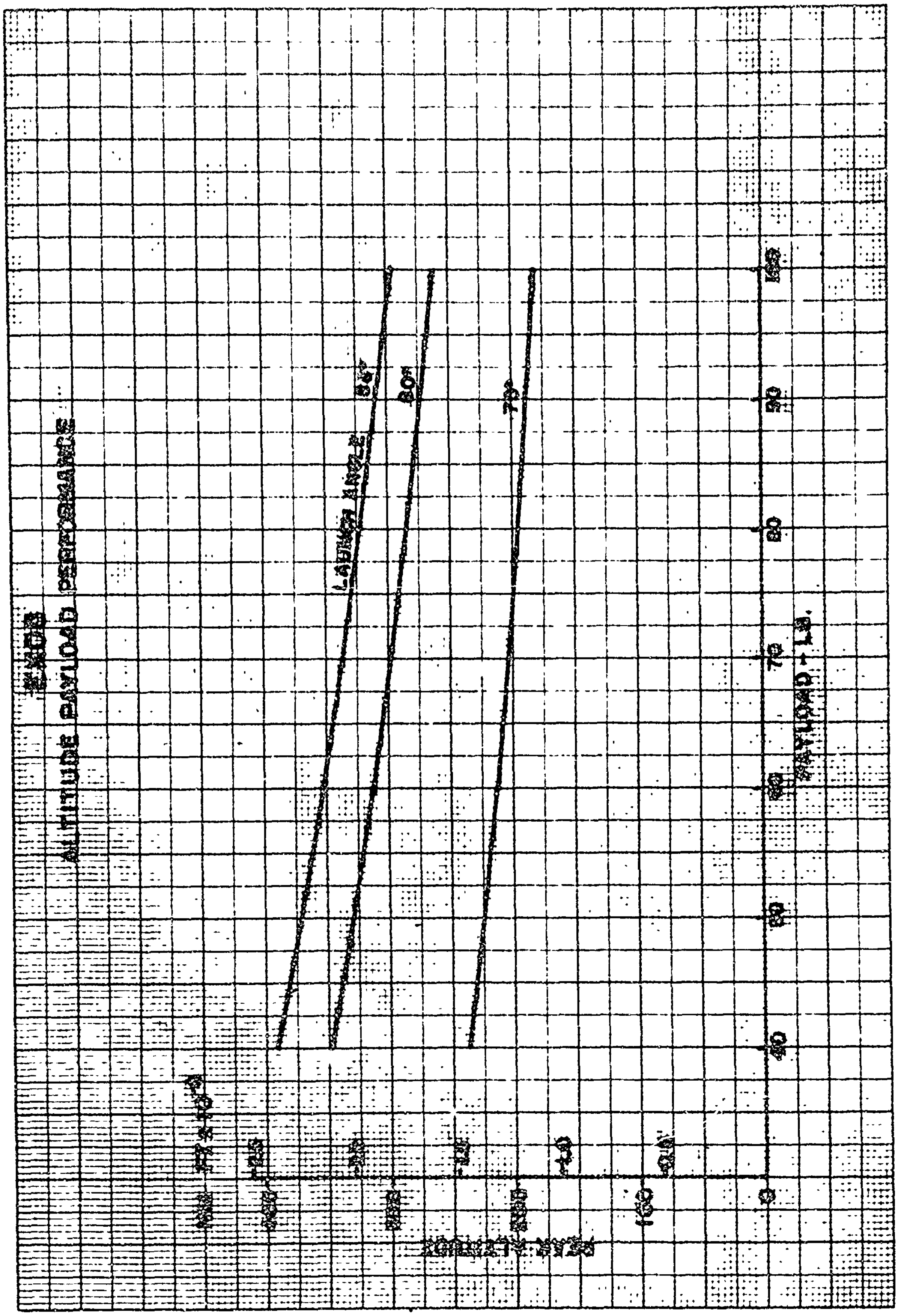


	WEIGHT LB	PROPELLANT CONSUMED LB
PAYLOAD COMPARTMENT	25	
YARDBIRD 4.6 – KS-14700 (TE 289-1) FUELED	389.2	268
NIKE M5- 2.5 DS-59000 FUELED	1302.0	764
HONEST JOHN 4 DS-105000 FUELED	4164.0	2180
LAUNCH WEIGHT LESS PAYLOAD	5880.2	

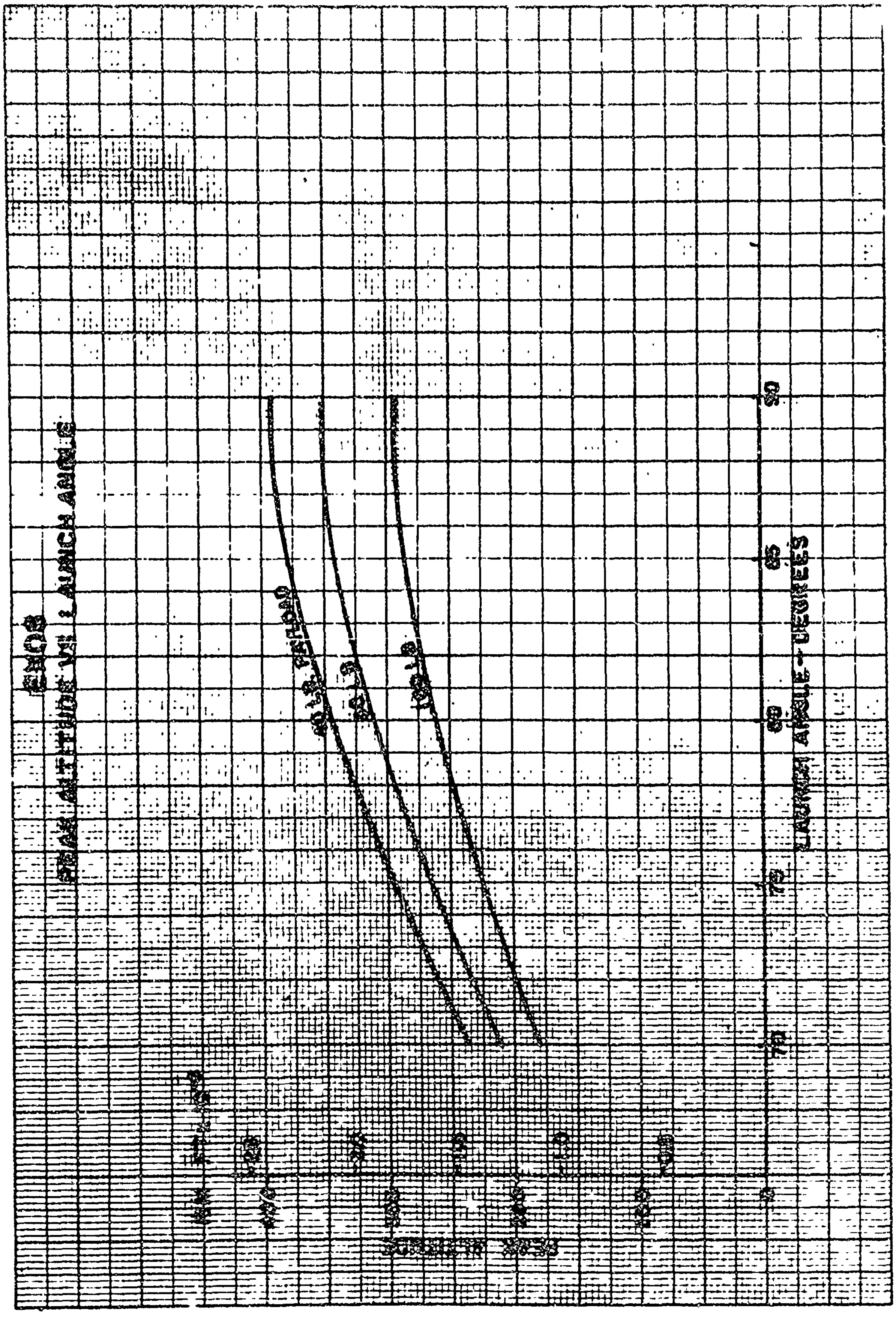
EXOS
PAYLOAD COMPARTMENT

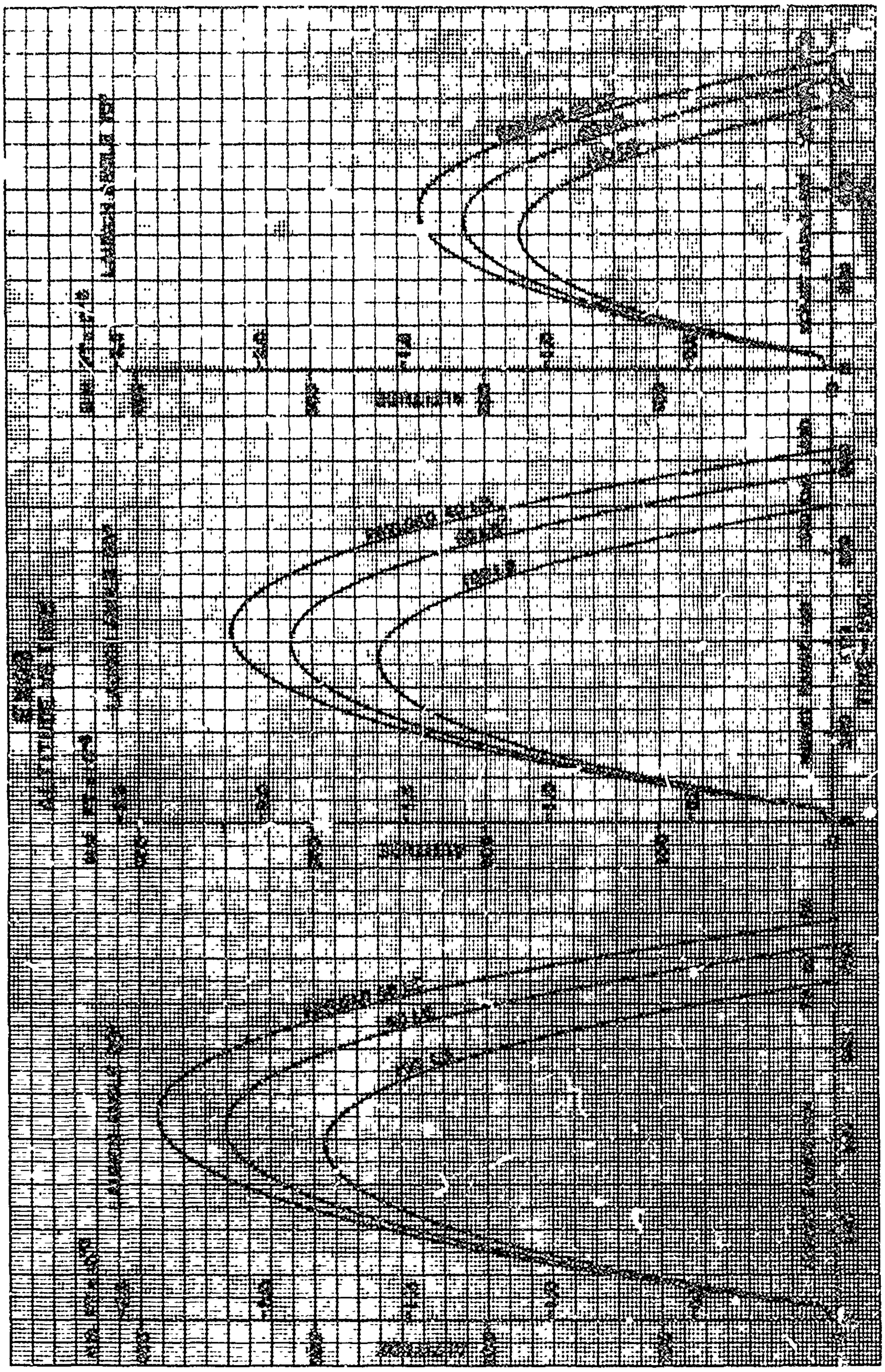


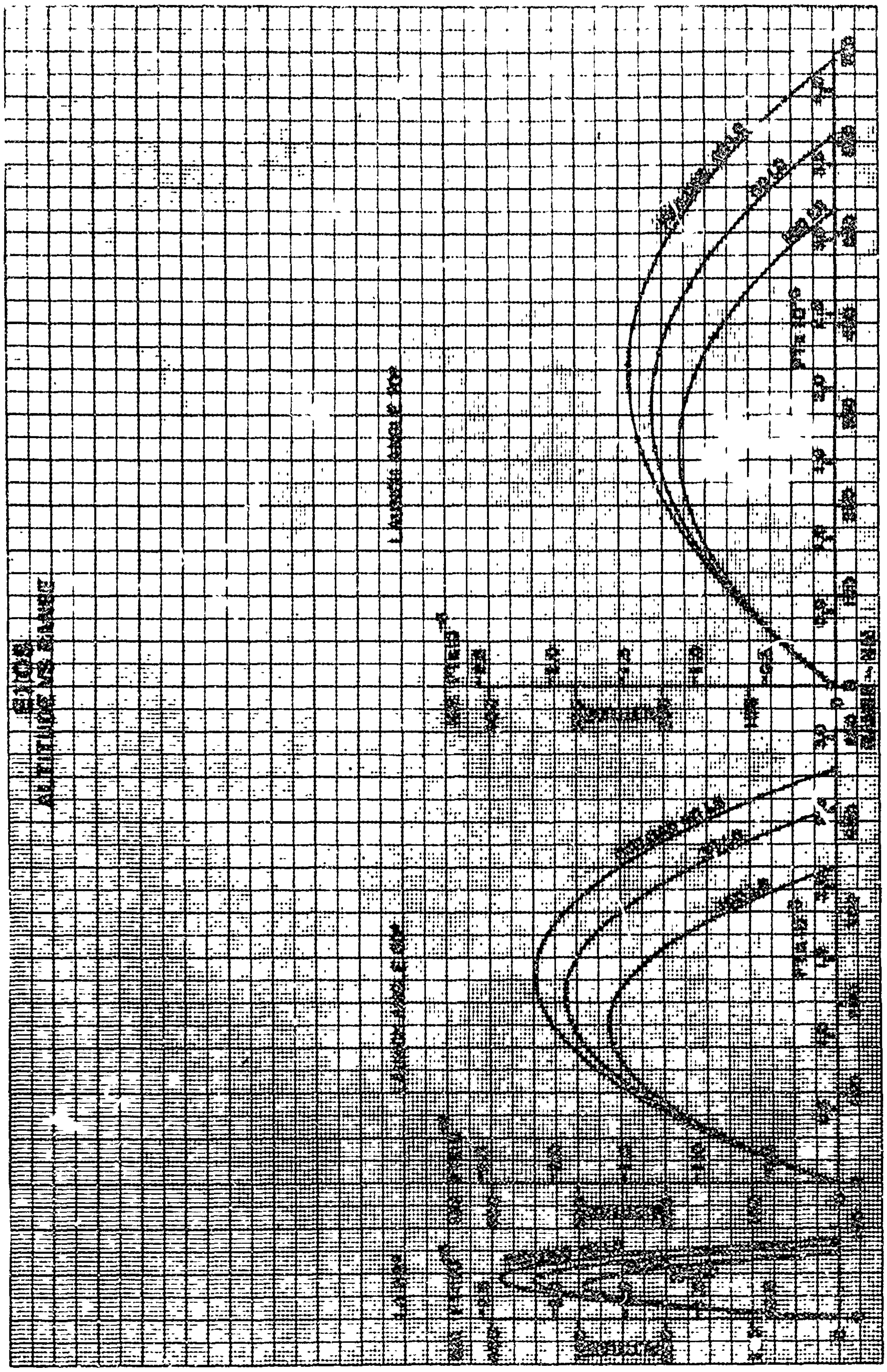
GROSS AVAILABLE PAYLOAD VOLUME
~1.0 CU.FT.

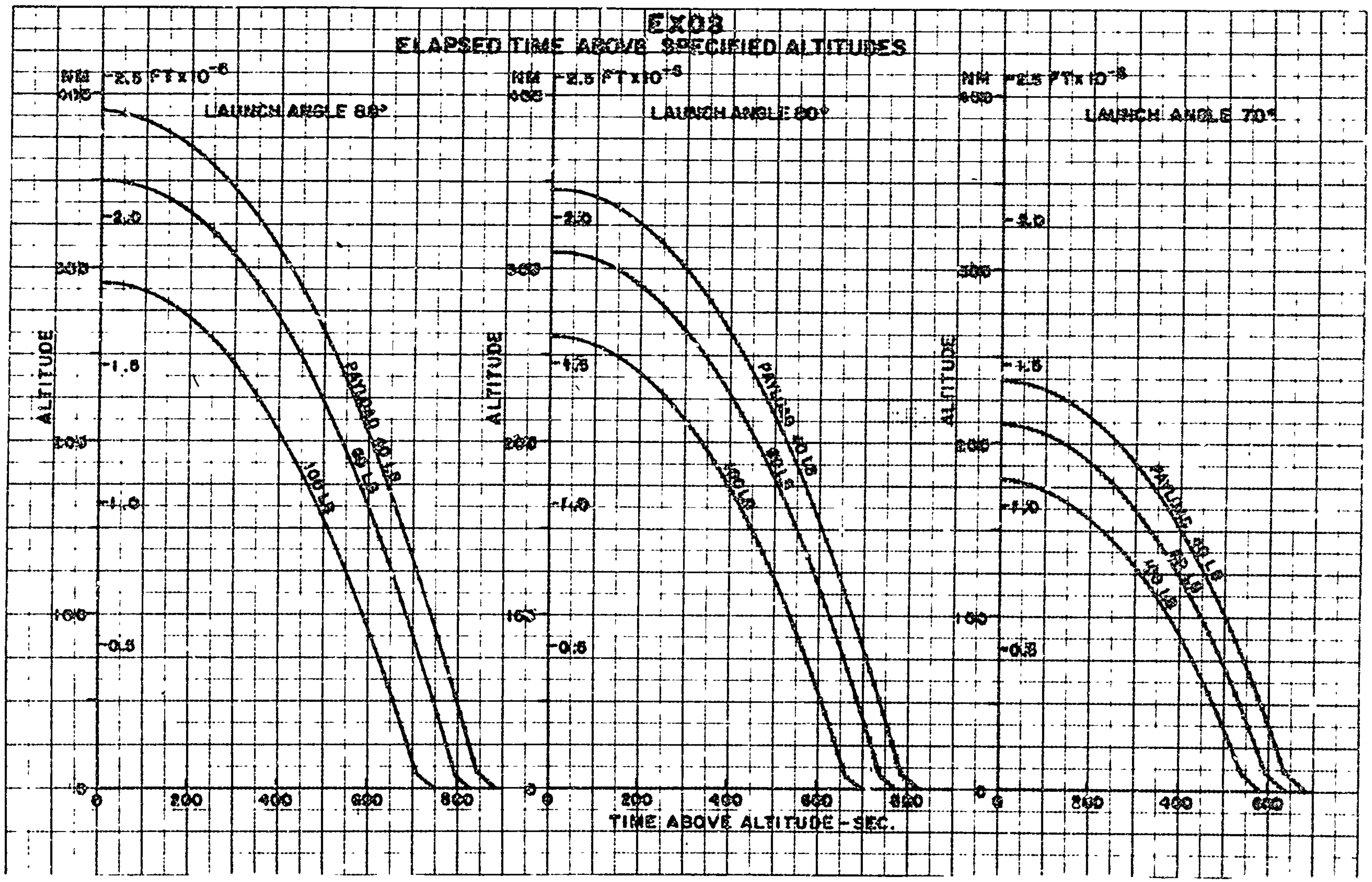

EXOS
ALTITUDE PAYLOAD PERFORMANCE
LAUNCH ANGLE
84°
80°
70°
PEAK ALTITUDE
FT x 10^-3
PAYLOAD - LB.
40
60
70
80
90
100
0
100

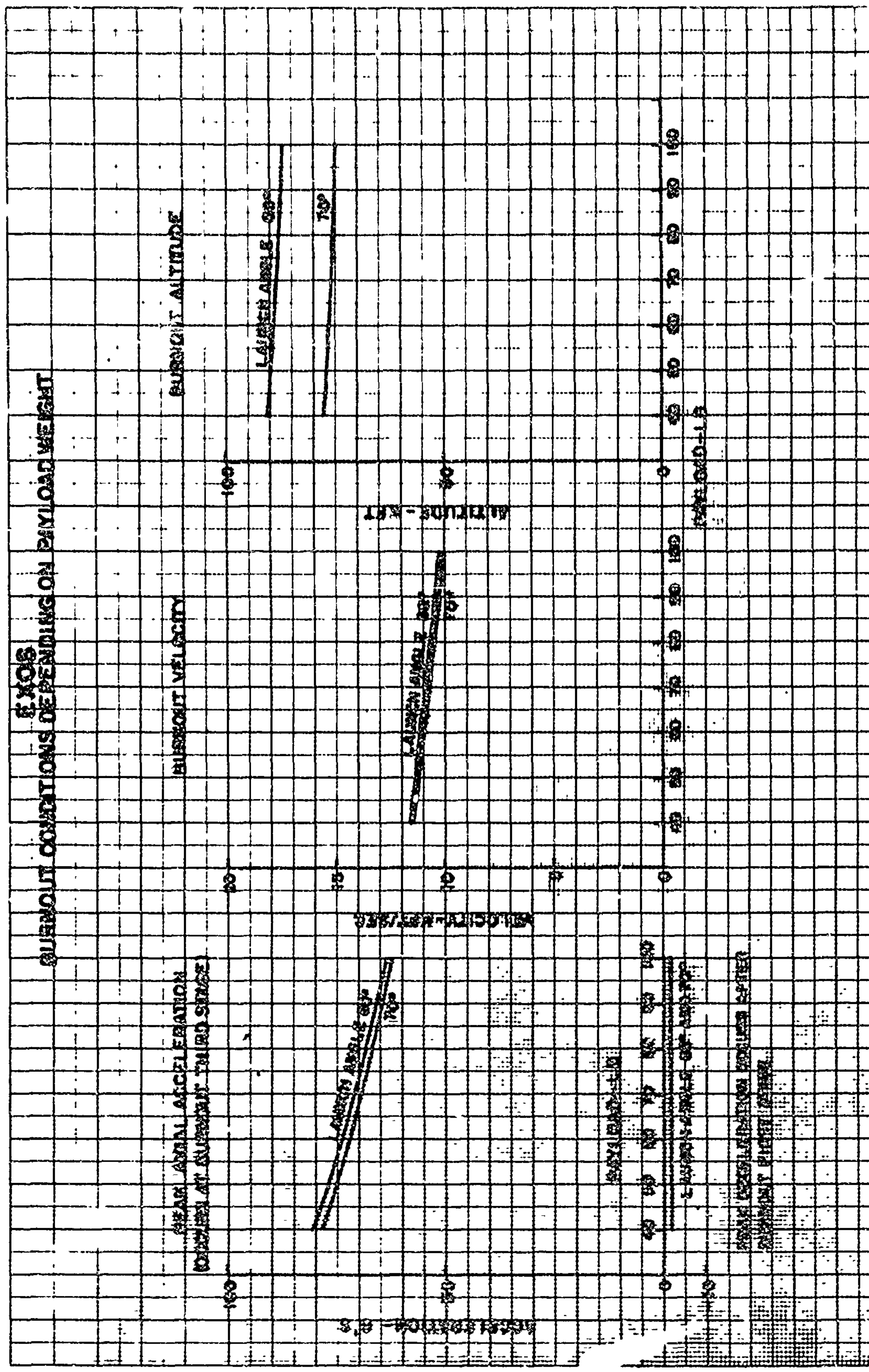
7-8

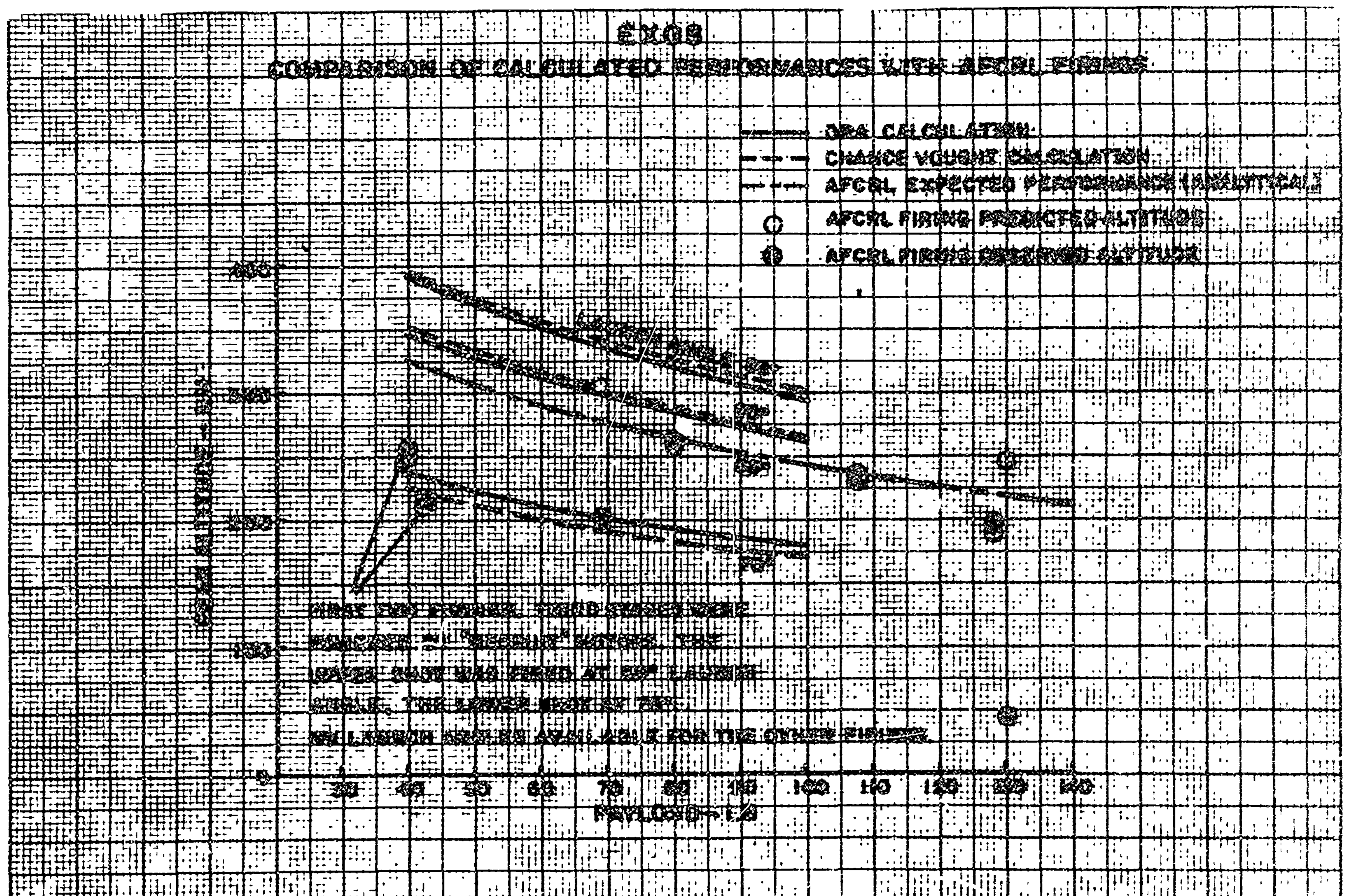

EXOS
PEAK ALTITUDE VS. LAUNCH ANGLE
LAUNCH ANGLE - DEGREES
70
75
80
85
90

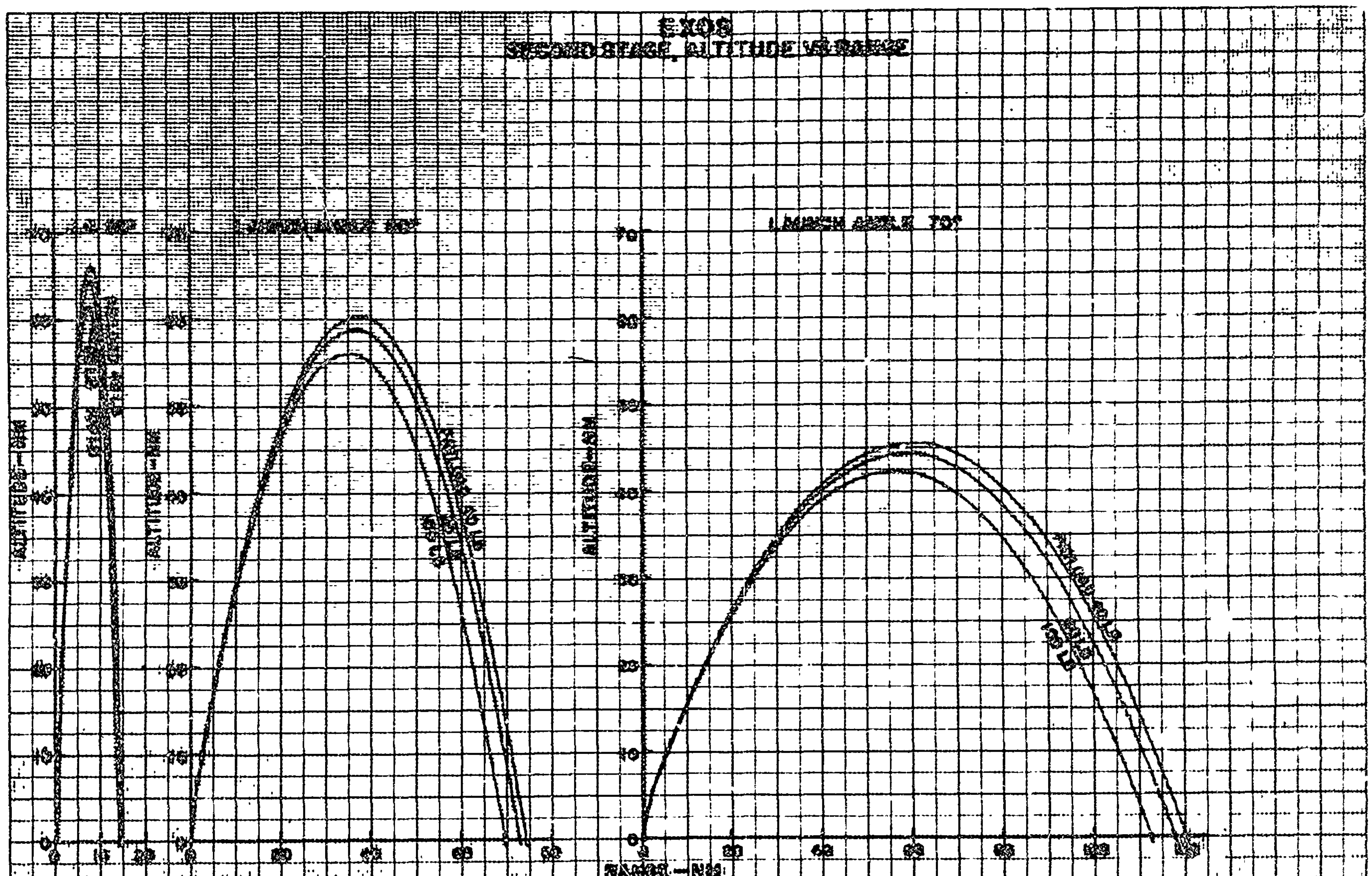



ALTITUDE VS RANGE


EXOS
ELAPSED TIME ABOVE SPECIFIED ALTITUDES
NM
ALTITUDE
LAUNCH ANGLE 88°
LAUNCH ANGLE 80°
LAUNCH ANGLE 70°
PAYLOAD 40 LB
60 LB
100 LB
TIME ABOVE ALTITUDE - SEC.


EXOS
BURNOUT CONDITIONS DEPENDING ON PAYLOAD WEIGHT
PEAK AXIAL ACCELERATION
(OCCURS AT BURNOUT THIRD STAGE)
BURNOUT VELOCITY
BURNOUT ALTITUDE
ACCELERATION - G's
VELOCITY - KFT/SEC
ALTITUDE - KFT
PAYLOAD - LB
LAUNCH ANGLE 80°
70°
PEAK ACCELERATION OCCURS AFTER BURNOUT FIRST STAGE


EXOS
COMPARISON OF CALCULATED PERFORMANCES WITH AFCRL FIRINGS
CHANCE VOUGHT CALCULATION
AFCRL EXPECTED PERFORMANCE (ANALYTICAL)
AFCRL FIRING PREDICTED ALTITUDE
AFCRL FIRING OBSERVED ALTITUDE
400
300
200
100
0
30
40
50
60
70
80
90
100
110
120
130
140
PAYLOAD – LB


EXOS
SECOND STAGE, ALTITUDE VS RANGE
LAUNCH ANGLE 80°
LAUNCH ANGLE 70°
ALTITUDE—NM
RANGE—NM

EXOS

GROUND SUPPORT EQUIPMENT

Launcher

The EXOS can be launched from a modified Honest John launcher or from a NASA modified I-Beam Honest John or Sergeant launcher. Launchers are installed at Atlantic Missile Range, Eglin Air Force Base, Pacific Missile Range and White Sands Missile Range. Standard Honest John riding lugs are used.

Handling Equipment

The following equipment is needed:

2 modified bomb lift trailers
high lift fork truck, 4000 lb capacity
mobile crane, 2000 lb capacity
strong back, 4000 lb capacity
booster hoist beam and 2 sling assemblies

Electrical Equipment

Necessary to check firing squibs, igniter, circuitry, timer and batteries.

EXOS

AERODYNAMIC HEATING
AND
HEATING OF PAYLOAD COMPARTMENT

The aerodynamic heating of the EXOS is more severe than that of the Aerobee 150 and Nike-Cajun, and heat protection of the payload compartment is necessary. To protect the vehicle against excessive aerodynamic heating a 25 second coasting period was arranged between first stage burnout and second stage ignition. In this period the vehicle travels at a modest speed through the denser part of the atmosphere to approximately 40,000 feet altitude, where the air density is sufficiently low to preclude excessive aerodynamic heating. Two types of heat protected nose cones have been flown successfully in the AFCRL firings: A heat sink type using a solid nickel nose tip as heat sink (which served simultaneously as telemetry dipole antenna), and an ablative skin type. No unusual heating problems have been encountered in using these two types of payload compartments.

Heat protection for the magnesium second stage fins is provided by Inconel cuffs on the leading edges. Payload components mounted externally, like antennas etc., must be carefully designed to withstand aerodynamic heating.

Measurements of the maximum internal skin temperature of an Inconel nose cone, taken by AFCRL during the second EXOS flight, show temperatures of $370^{\circ} \pm 50^{\circ}$F at a station 15 inches from nose tip and $220^{\circ} \pm 20^{\circ}$F in the cylindrical section of the nose cone, 55 inches from nose tip. The flight conditions were 80° launch angle and approximately 40 lbs payload.

It should be noted that the aerodynamic heat input is only one of several parameters which determine the internal temperature of the payload. None of these parameters might be severe, however the summation of all can exceed toleration limits. Therefore internal heating should be checked for every different payload and launch condition.

ASTROBEE 200

ASTROBEE 200

VEHICLE DESCRIPTION

Name of Vehicle	Astrobee 200
Designation	AJ 60-27
Manufacturer	Space General Corporation El Monte, California, a Subsidiary of Aerojet General Corporation
Kind of Vehicle	2 stage, solid propellant, fin stabilized probe vehicle
First Stage Motor	Nike M5, 2.5-DS-59000(X216-A2) Radford Arsenal
Second Stage Motor	Alcor, 30-KS-8000A Aerojet General Corporation
Payload-Altitude Capability for 88° Launch Angle	110 lb - 130 N. M. 150 lb - 116 N. M. 250 lb - 89 N. M.
Payload Volume	3.6 cu. ft. nose cone 6.1 cu. ft. nose cone plus extensions
Peak Acceleration Peak Deceleration	18.3 G's (110 lb payload, 88° L. A.) 4.35 G's (110 lb payload, 70° L. A.)
Max. Velocity	6400 FPS (110 lb payload, 88° L. A.)
Launch Weight less net payload	2668 lb
Reliability	3 successes out of 4 firings
User	USAF (AFCRL)
Sources	Space General, Aerojet General, ABL, AFCRL, Ling-Temco-Vought. Performance Computation: AFMDC Analog Computation Division

ASTROBEE 200

The solid propellant Astrobee 200 was designed by Space General Corporation in 1960 as a replacement for the liquid fuel Aerobee 150. The objective was to simplify handling and servicing, to shorten the operational readiness time, to eliminate extensive ground facilities like expensive launching towers and handling and storage facilities for liquid propellants, and to make the vehicle less dependent on particular launching sites. In addition a small improvement of the altitude performance was intended, keeping the maximum acceleration at the low level of about 18 G's (Aerobee 150 - 12 G's). All these objectives have been attained.

Based on four firings by AFCRL the flight stability of the vehicle is considered fair. Its flight properties are insensitive to small external payload modifications.

Vibration measurements have not been made for the Astrobee 200. However the Nike motor is known for its low frequency longitudinal and lateral vibrations during ignition at the ± 25 G level. Vibration measurements of the 30-KS-8000A as flown in an Astrobee 500 indicate that this motor burns smooth. No serious structural dynamic problems have been observed during operation of the Astrobee 200.

A payload recovery system required for many experiments is under development.

The time required to prepare the Astrobee 200 for flight is about 4 manweeks (Aerobee 150 - 5 manweeks).

However there are several items which should be improved before the vehicle is considered competitive with the Aerobee 150: The inexpensive Nike motor has been used for the first stage but the cost of the vehicle is considerably higher than that of the Aerobee 150. The temperature range for operation and storage of the second stage motor, 30-KS-8000A, is restricted to values between 60°F and 100°F. The minimum storage life is one half year. In transport, the motor seems to be susceptible to damage and has to be handled with extra care (two cases of damage reported).

After the manufacturing of the first five vehicles a weight reduction program was conducted by Space General which resulted in weight savings of approximately 55 lbs. This was achieved by replacing the aluminum nose cone with a fiberglass nose cone, by substituting the fiberglass heat insulation of the 30-KS-8000A motor by a cork-phenolic binder insulation and by replacing steel and aluminum interconnecting structure with magnesium. No information has been received regarding test flight of the reduced weight vehicle.

The firing sequence is the following: The first stage burning time is 3.5 seconds. Thereafter the vehicle consisting of first and second stage coasts for 10.5 seconds. At the end of the coasting period the second stage motor is ignited by an electronic programmer and separation from the first stage is provided by a standard NASA blow-out diaphram. The second stage burns for 31.8 seconds. The total time from first stage ignition to burnout of the second stage is 45.8 seconds.

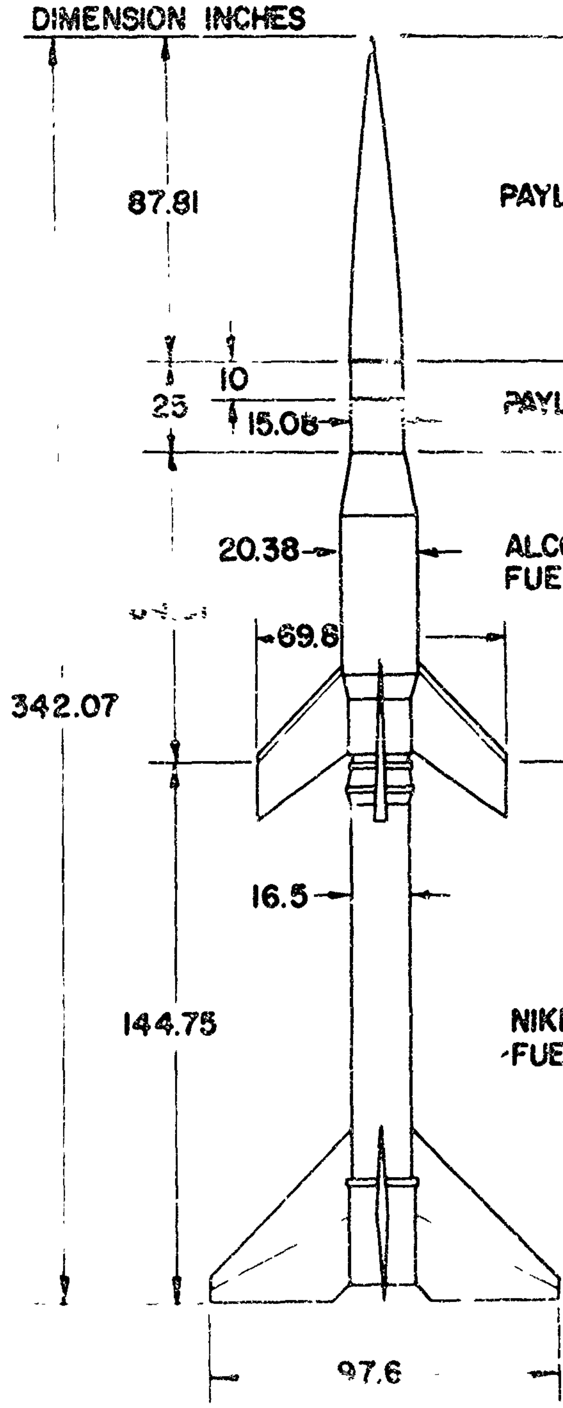
In the performance comparison graph (Page 8-14) the calculated performances of Space General and the altitudes observed in AFCRL firings are better than the performances calculated by Chance-Vought and ORA. Information received from Space General indicates that their performances were calculated without payload extensions while the calculations of both Chance-Vought and ORA include payload extensions. The altitude-payload performance curve of Space General will produce realistic values for the version without extensions. It is practically identical with expected performances of AFCRL, which are not shown in the graph.

The only failure which occurred in the four firings was due to an experimental graphite used in the nozzle insert of the second stage which broke. All subsequent 30-KS-8000 motors have been built with the original graphite insert which never showed any malfunctions. Therefore AFCRL expressed the opinion that the Astrobee 200 appears to be the only solid propellant vehicle in the Aerobee 150 class which has a promising reliability.

ASTROBEE 200

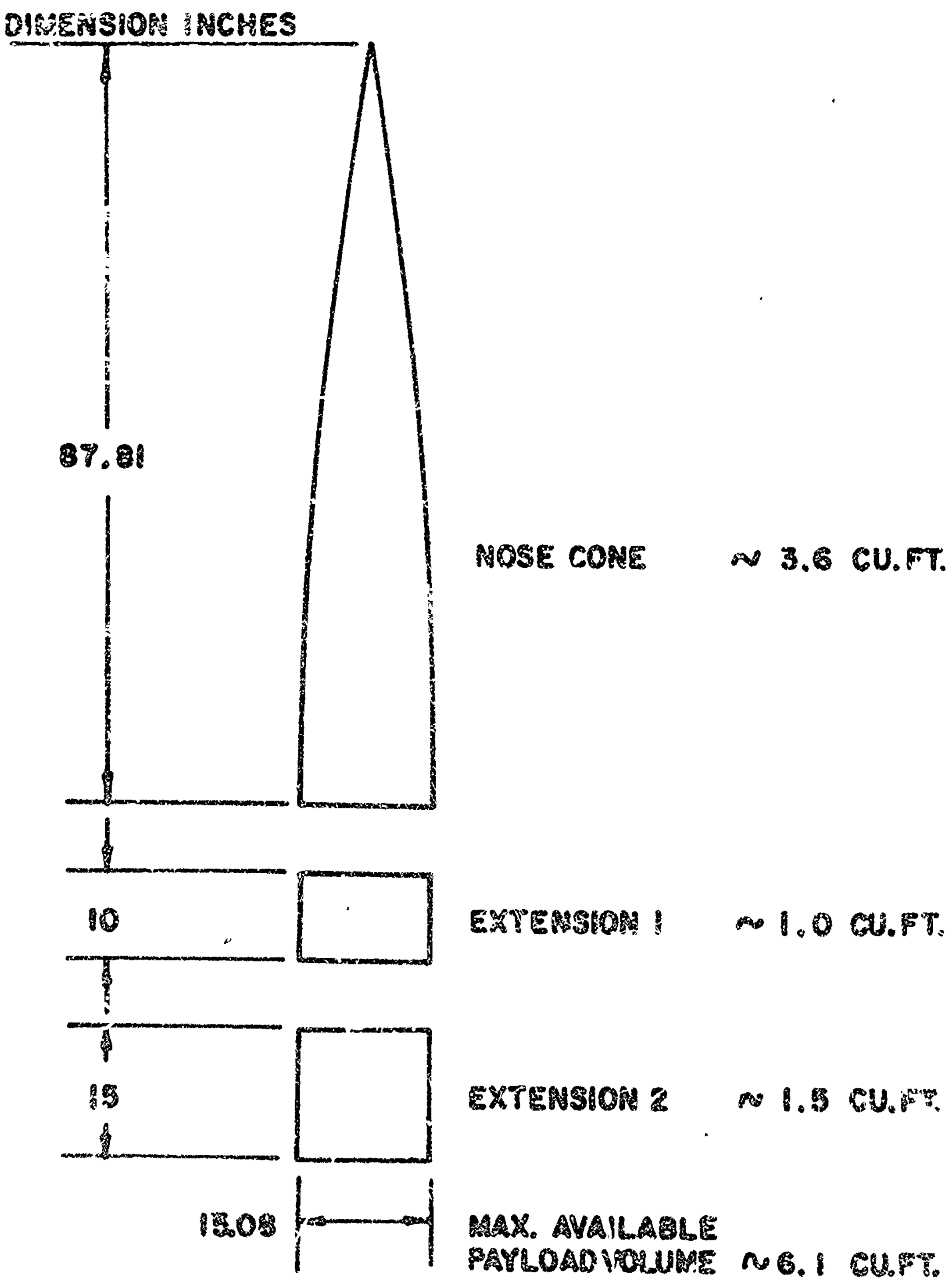
ASSEMBLY, DIMENSIONS AND WEIGHTS

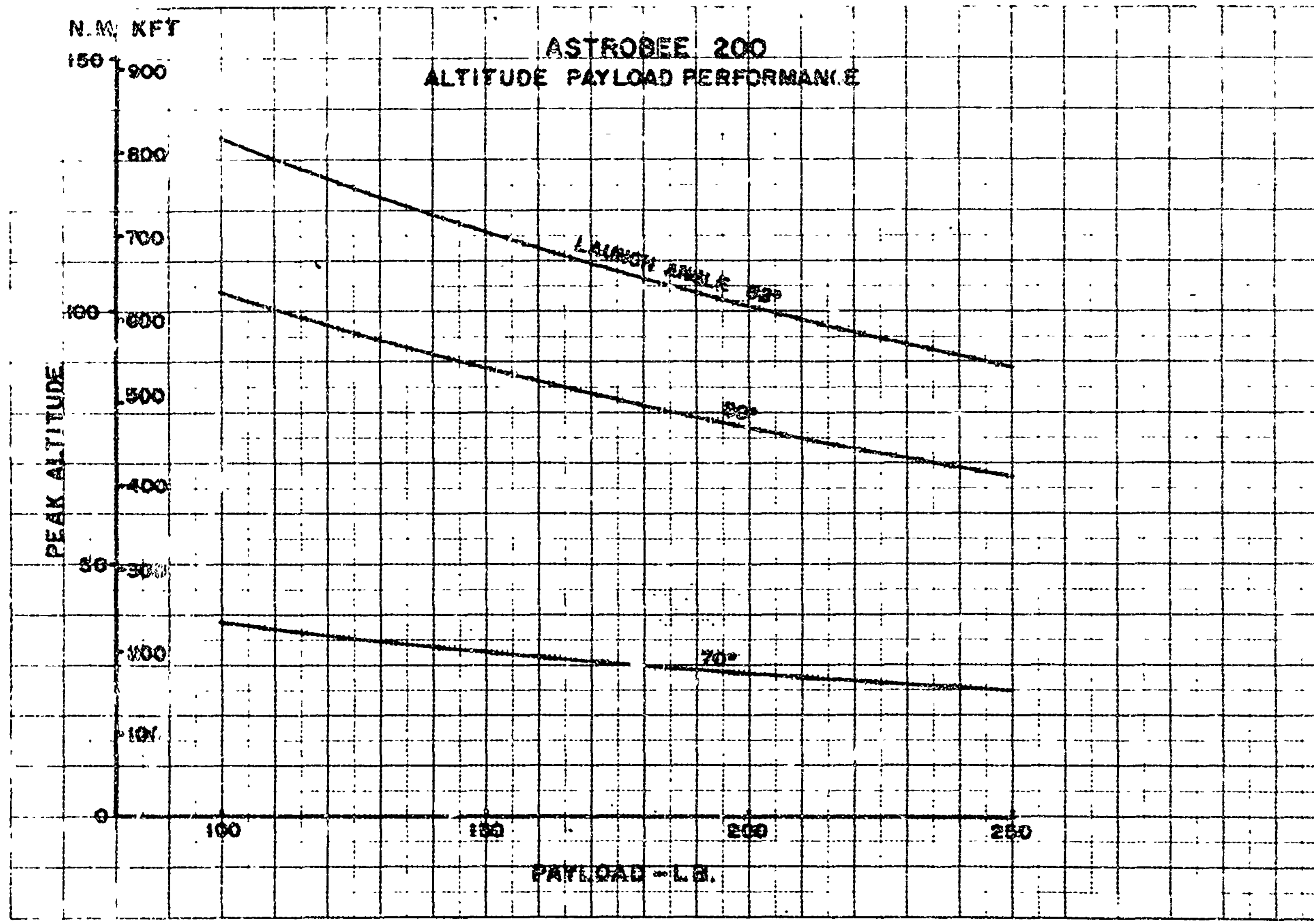
PAYLOAD 110-250 LB

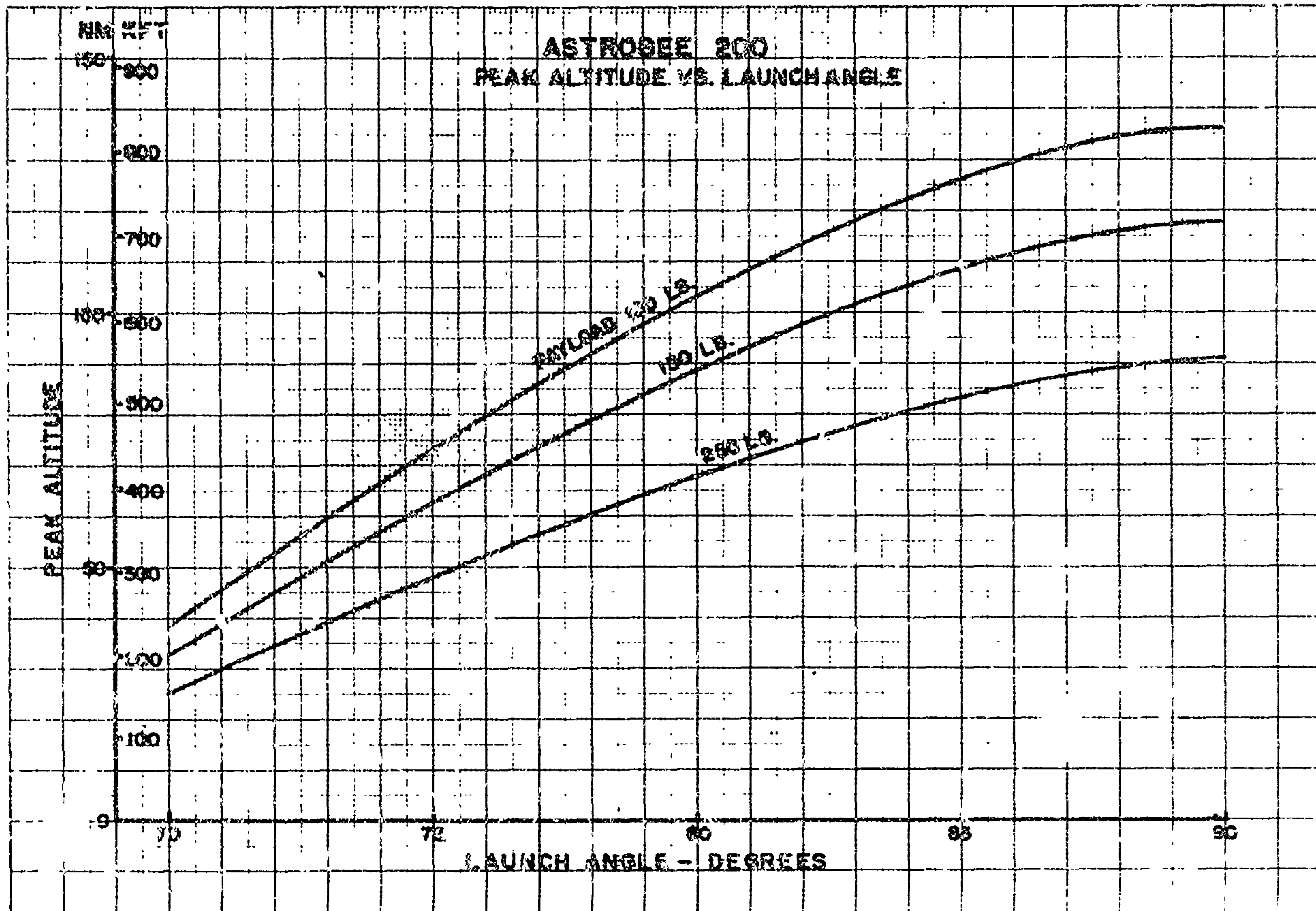


	WEIGHT LB	PROPELLANT CONSUMED LB
PAYLOAD COMPARTMENT	36.7	
PAYLOAD EXTENSIONS	26.4	
ALCOR, 30 KS-8000 A FUELED	1129.6	878.6
NIKE M5, 2.5 DS-59000 FUELED	1475.3	764
LAUNCH WEIGHT LESS PAYLOAD	2668.0	

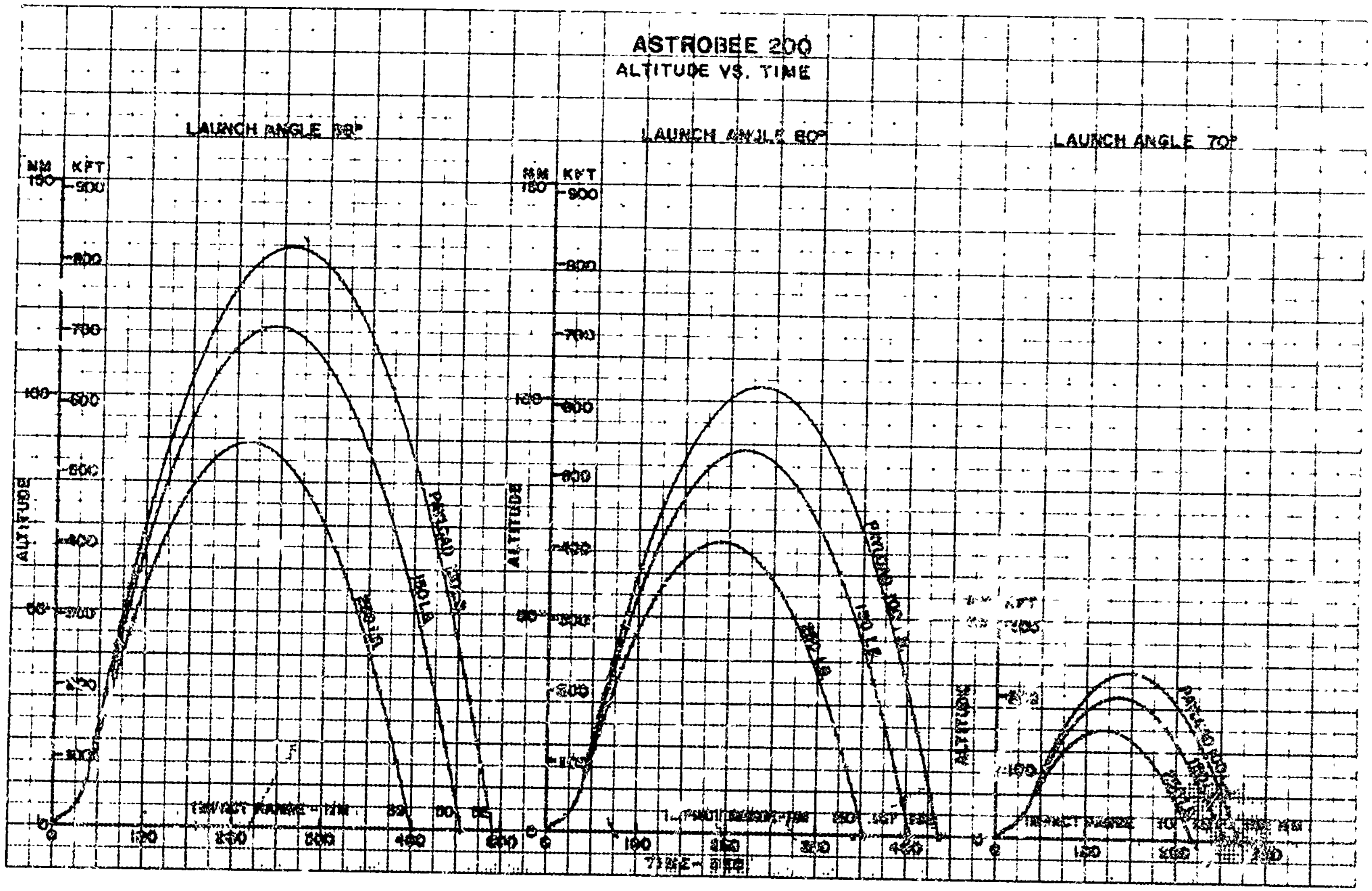
ASTROBEE 200
PAYLOAD COMPARTMENT




ASTROBEE 200
ALTITUDE PAYLOAD PERFORMANCE
N.M. KFT
PEAK ALTITUDE
LAUNCH ANGLE
70°
PAYLOAD - LB.
100
150
200
250
0
50
100
150
900
800
700
600
500
400
200

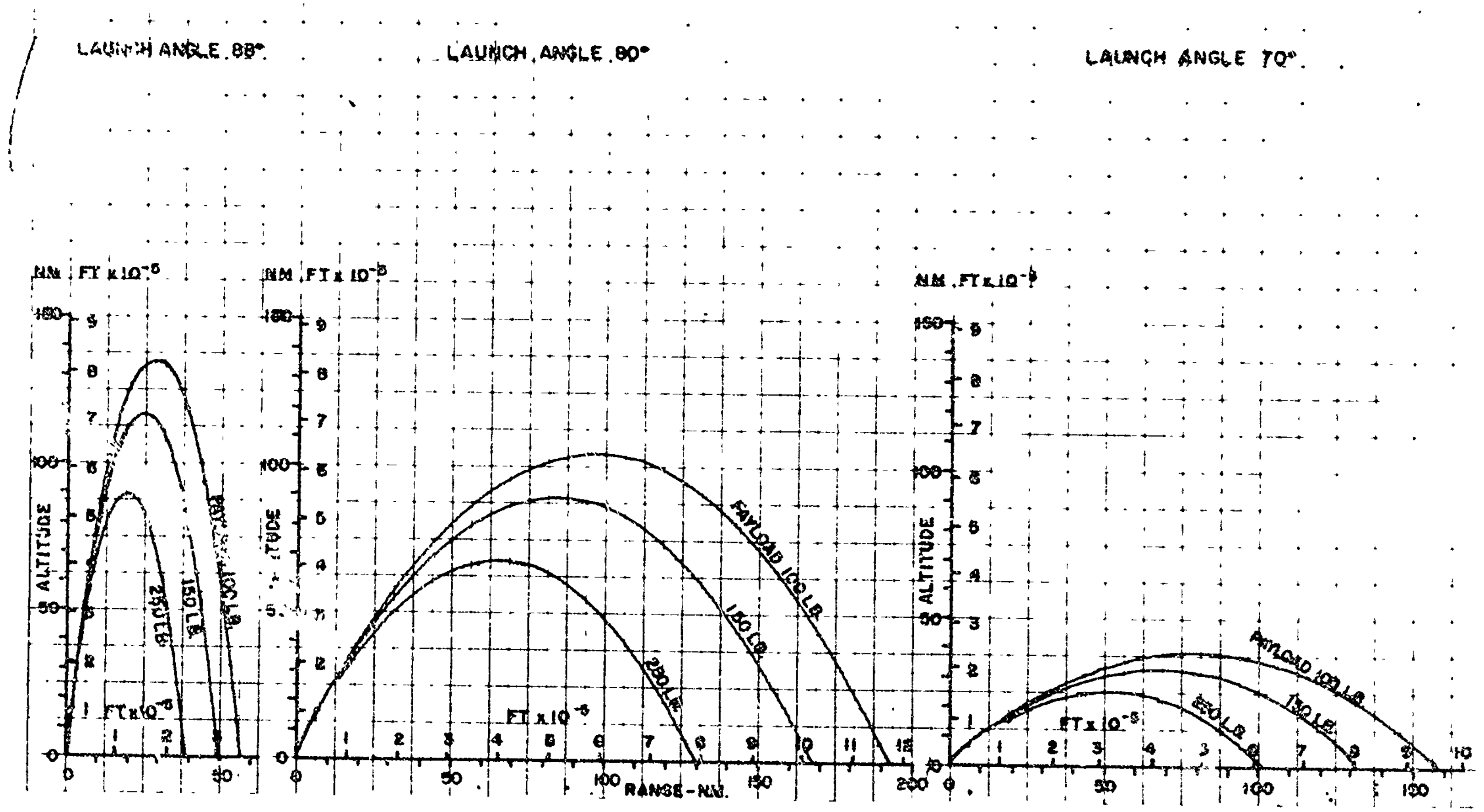


ASTROBEE 200
PEAK ALTITUDE VS. LAUNCH ANGLE
NM
KFT
PEAK ALTITUDE
150
100
50
0
900
800
700
600
500
400
300
200
100
PAYLOAD
150 LB.
250 LB.
70
75
80
85
90
LAUNCH ANGLE – DEGREES

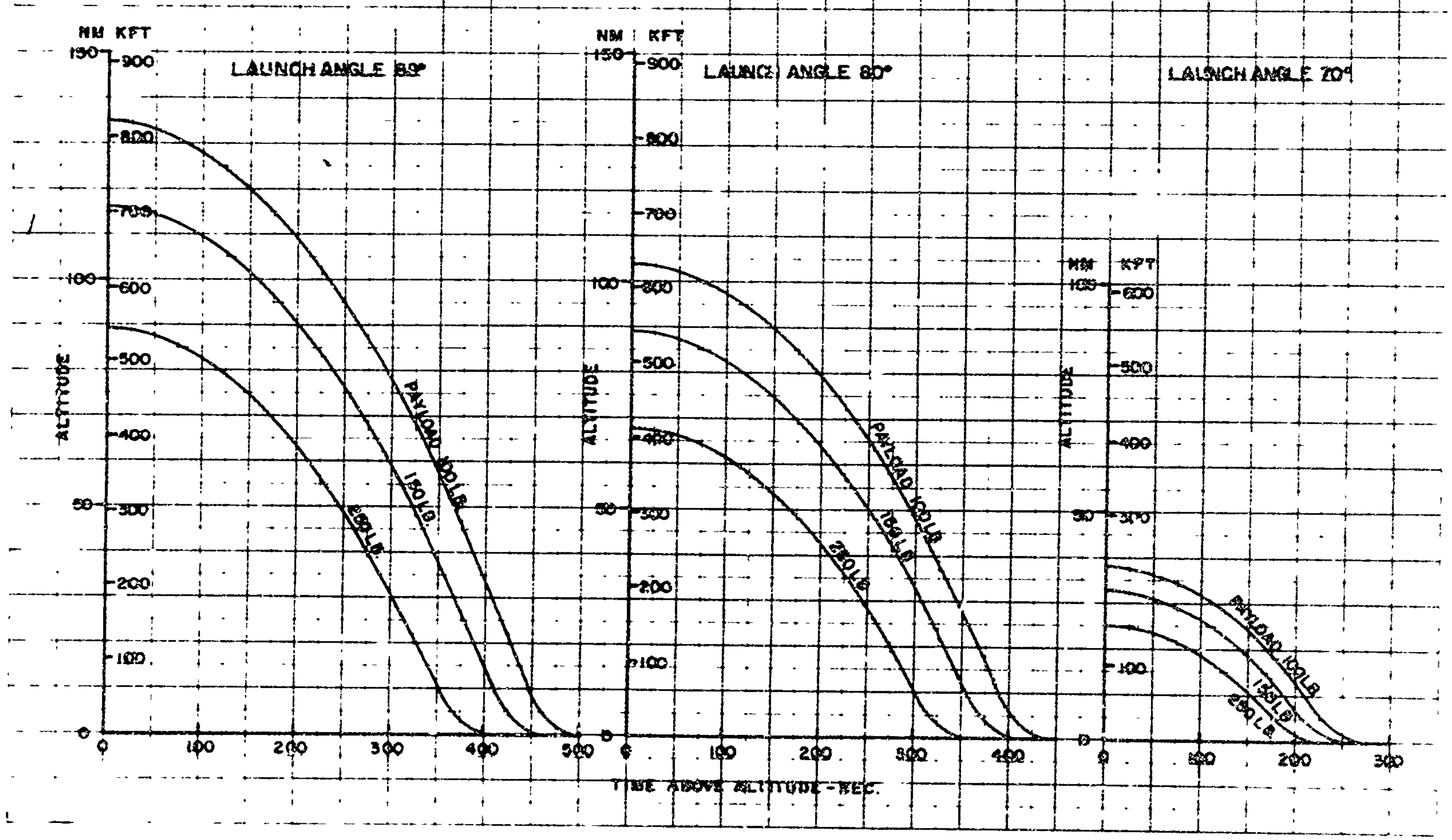

ASTROBEE 200
ALTITUDE VS. TIME
LAUNCH ANGLE 80°
LAUNCH ANGLE 70°
NM
KFT
ALTITUDE
PAYLOAD 100 LB
150 LB
IMPACT RANGE - NM
TIME - SEC

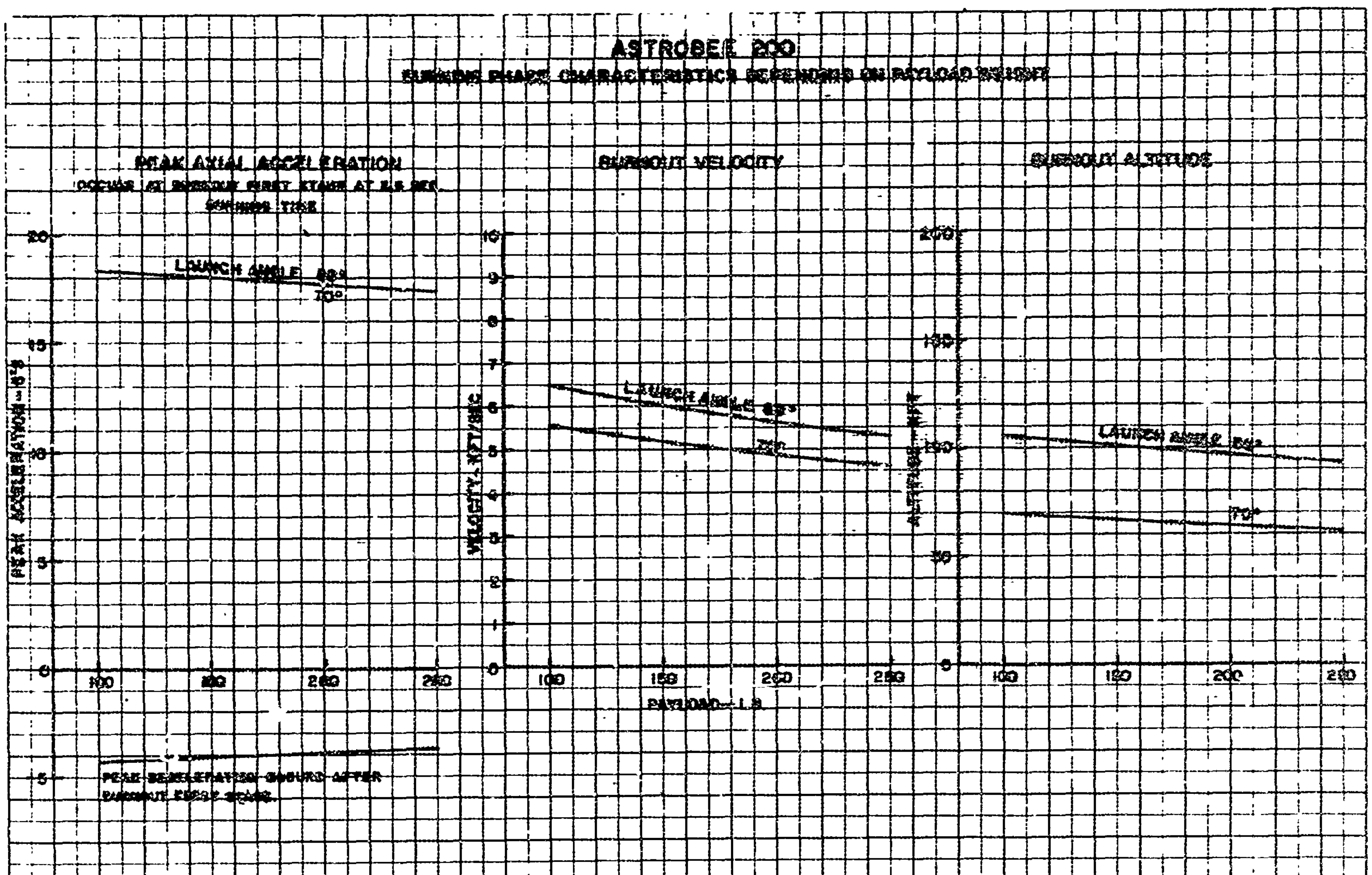
ASTROBEE 200

ALTITUDE VS RANGE

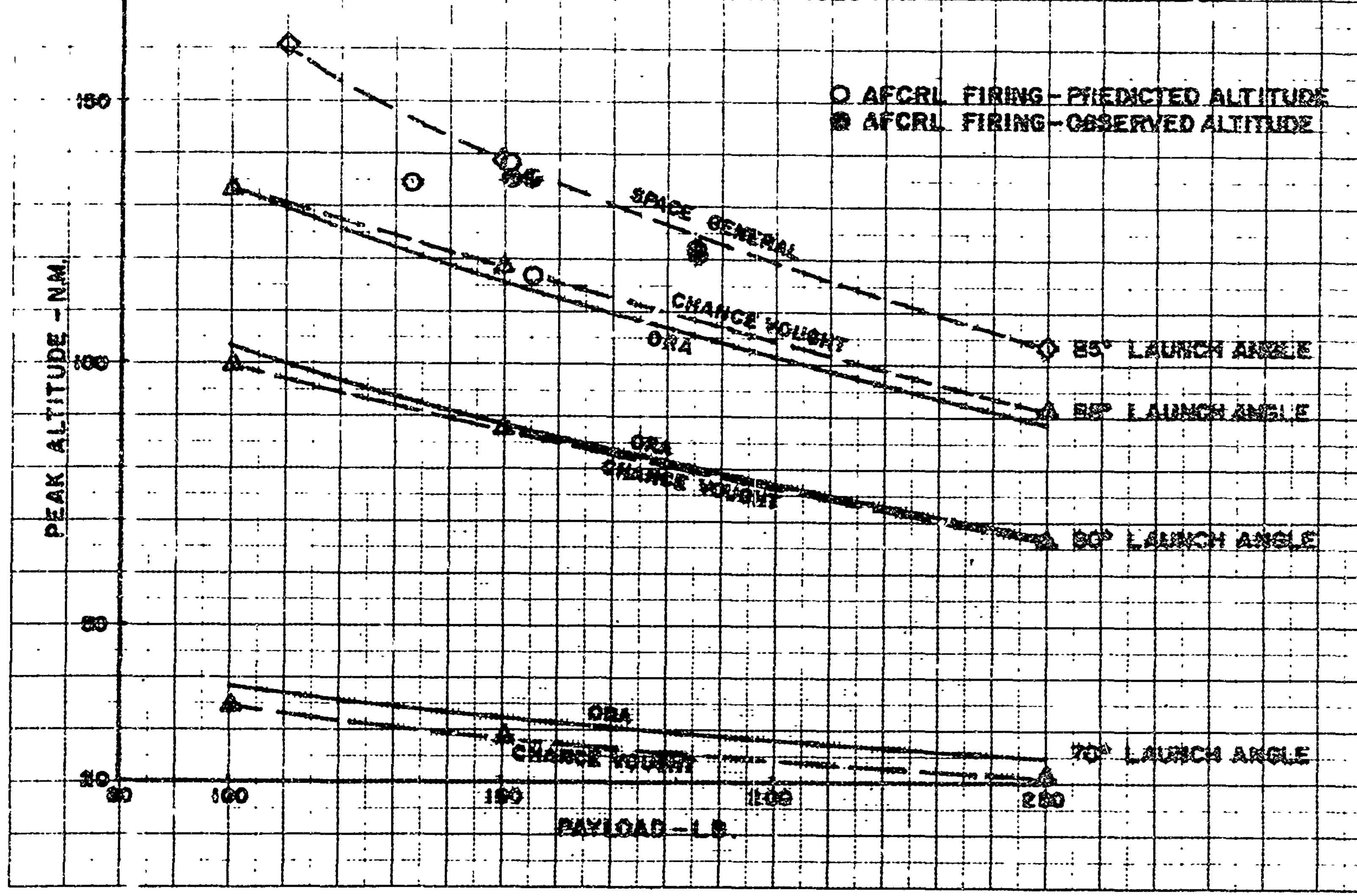


ASTROBEE 200
ELAPSED TIME ABOVE SPECIFIED ALTITUDES




ASTROBEE 200
PEAK AXIAL ACCELERATION
BURNOUT VELOCITY
BURNOUT ALTITUDE
LAUNCH ANGLE
70°
VELOCITY - KFT/SEC
PAYLOAD - LB

ASTROBEE 200
COMPARISON OF COMPUTED PERFORMANCES AND AFCRL FIRINGS AT APGC



ASTROBEE 200

GROUND SUPPORT EQUIPMENT

Launcher

The Astrobee 200 has been launched from the Ryan-Aerolab general purpose launcher at Eglin Air Force Base. However it can be adapted easily to other boom launchers.

Handling Equipment

The following handling equipment is required:

Booster hoist beam and
sling assembly
Fork lift truck
Modified bomb lift trailer,
4000 lbs
Nike cradle
30-KS-8000 cradle

Electrical Support Equipment

Necessary to check firing squibs, igniters, circuitry and electronic programmer.

ASTROBEE 200

AERODYNAMIC HEATING AND HEATING OF PAYLOAD COMPARTMENT

For launch angles larger than 75° the aerodynamic heating of the Astrobee 200 is not severe. It is comparable to the heating conditions of the Aerobee 150. For launch angles lower than 75° and low payload weights the aerodynamic heat input increases considerably and additional protection will be necessary. The manufacturer claims that the temperature in the payload compartment does not exceed 200°F for a launch angle of 85° and a payload weight of 110 lbs. AFCRL experiences in their firings at Eglin AFB are that no unusual difficulties have been encountered in protecting the instrumentation from aerodynamic heating.

The second stage is equipped with the following heat protection: The leading edges of the fins are protected. The 30-KS-8000A motor case has an ablative coating to keep its temperature below 250°F during flight.

The aerodynamic heat input is only one of many parameters which determine the internal temperature of the payload. The heating inside the payload compartment depends on temperature at launch, heat output of the payload, outside air temperature during flight, aerodynamic heat input, sun radiation, heat insulation of payload compartment, absorptivity, emissivity and heat conduction properties of the skin material. While none of these parameters might be severe, the summation of all can exceed toleration limits. Internal heating should be checked for every different payload and launch condition.

BLACK BRANT III

BLACK BRANT III

VEHICLE DESCRIPTION

Name of Vehicle	Black Brant III
Manufacturer	Canadian Bristol Aerojet Limited Winnipeg, Manitoba, Canada
Kind of Vehicle	One stage, solid propellant, fin stabilized probe vehicle
Motor	9-KS-11000, Canadian Bristol Aerojet
Payload-Altitude Capability for 80° Launch Angle	25 lb - 80.2 N.M. 45 lb - 73.3 N.M. 75 lb - 64.5 N.M.
Payload Volume	1 - 1.35 cu. ft.
Peak Acceleration Peak Deceleration	30 G's (25 lb payload - 88° L.A.) 8 G's (25 lb payload - 70° L.A.)
Max. Velocity	6250 FPS (25 lb payload - 88° L.A.)
Launch Weight less net payload	631.0 lb
Reliability	4 successes out of 6 development firings (last two shots with final fins successful)
Users	(Vehicle under development)
Sources	Canadian Bristol Aerojet, Ling-Temco-Vought. Performance Computation: AFMDC Analog Computation Division

BLACK BRANT III

The Black Brant series of sounding rockets is a joint Canadian Government - Canadian industry development. The development team consists of the Canadian Department of Defense Production (DDP), the Defense Research Board (DRB), the National Research Council (NRC), and Canadian Bristol Aerojet Limited (CBA). The solid propellant motors used in the Black Brant program are developed by the Canadian Armament Research and Development Establishment (CARDE).

The Black Brant III is a single stage, three finned sounding rocket reaching altitudes up to 80 N. M. and covering a payload range from 25 lbs to 75 lbs. It was designed for a zero roll rate, however it can be spin stabilized, if desired. Until December 1962 six development test firings have been conducted at the Wallops Island, Virginia, range.

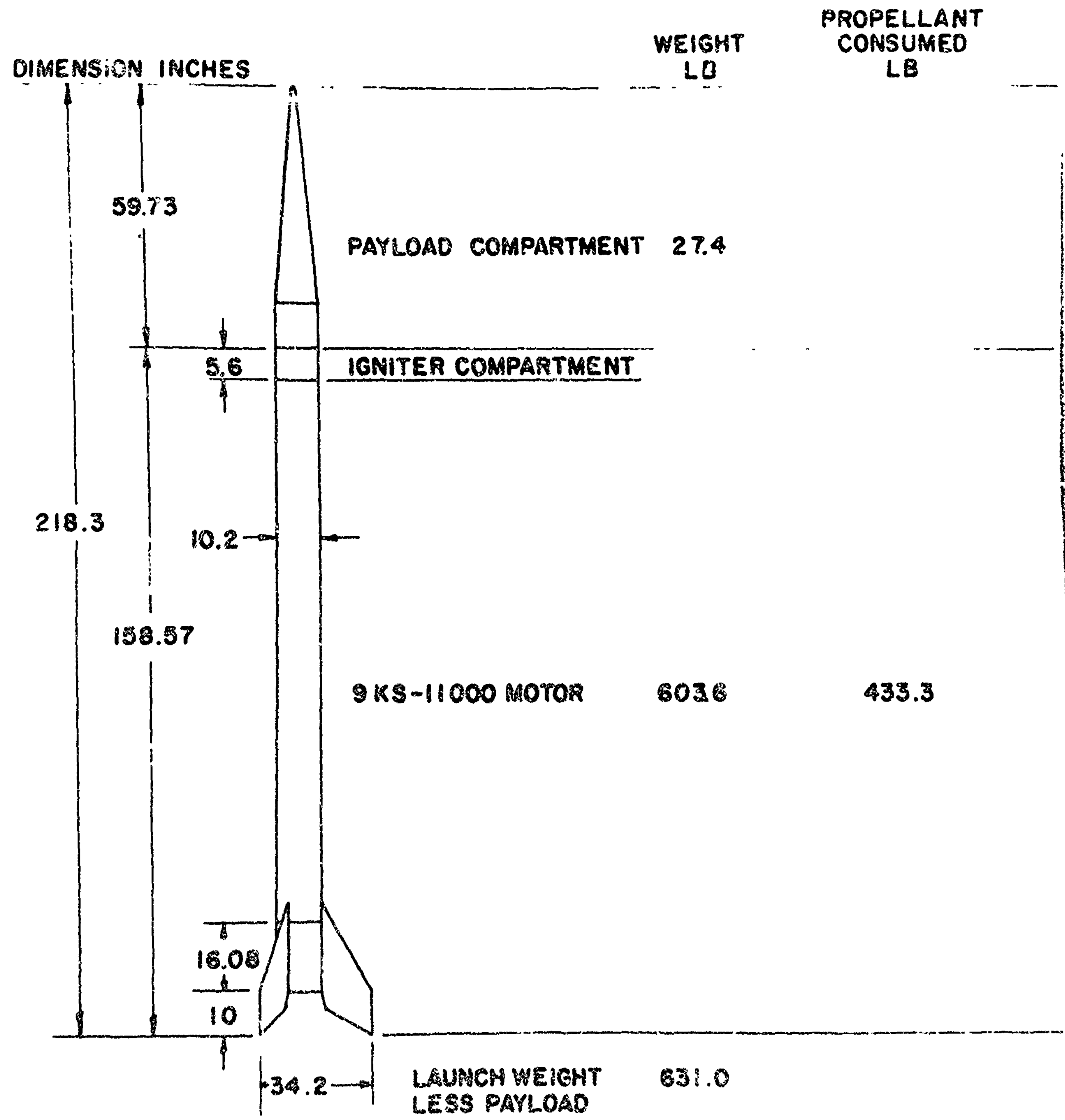
During the first four firings lateral disturbances in excess of 5 G's occurred due to aero-elasticity of the fins. There was no indication of structural failure during the disturbances which all occurred at 7 seconds flight time. Thereafter the vehicles trimmed out and continued to fly stable. After the installment of stiffer fins there was no evidence of disturbances during the last two flights which were conducted with payload weights of approximately 70 lbs. The achieved altitudes in these two flights were 97% and 99% of the estimated altitudes. Flights in the lower payload range with improved fins have not been conducted.

No motor problems were experienced in ignition and burning during the six test flights. The two failures mentioned in the preceding page "Vehicle Description" were caused by the lateral disturbances, which resulted in loss of telemetry and radar track in one case and abrupt changes in azimuth and elevation angle in the second case.

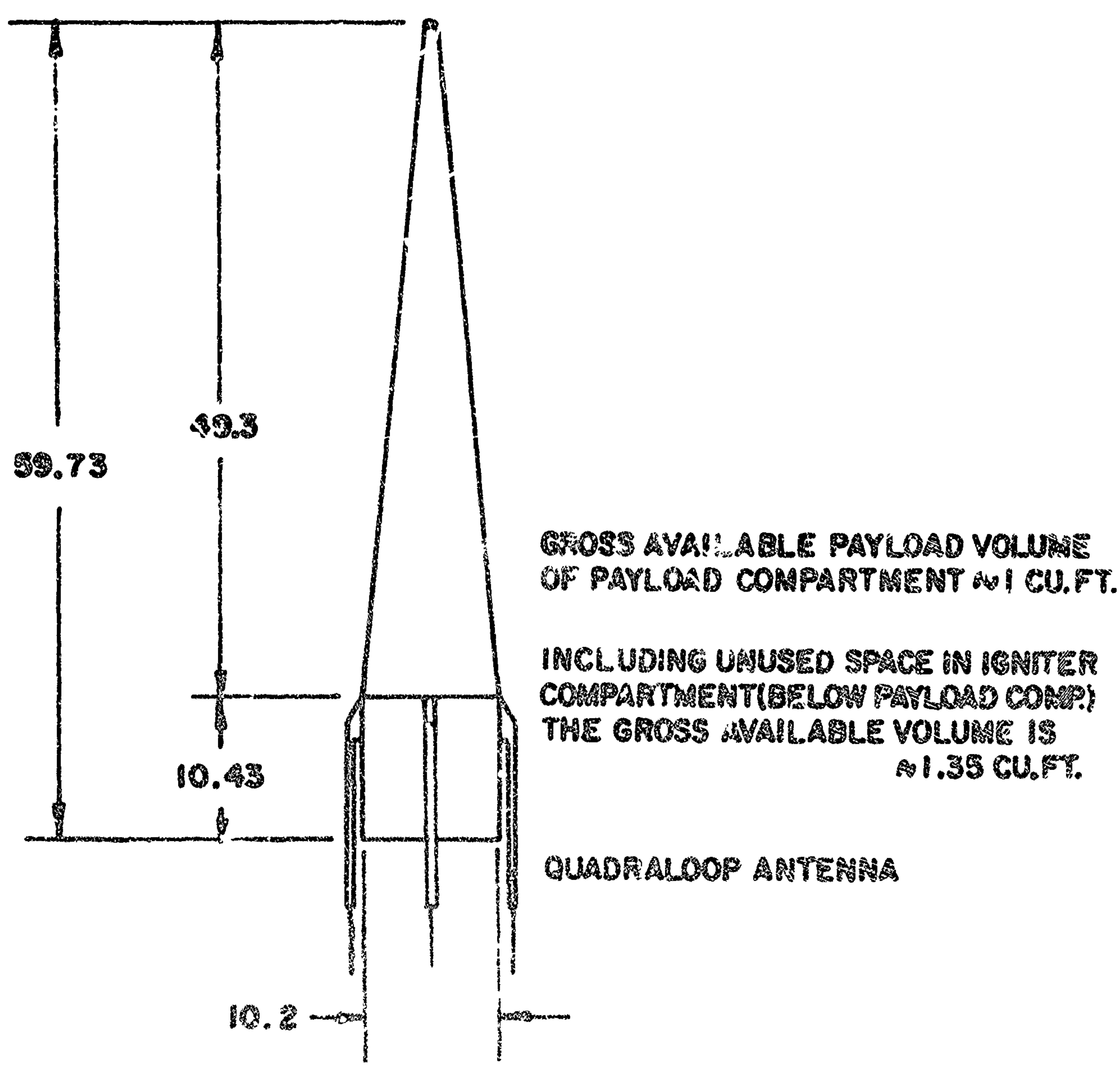
The total burning time of the 9-KS-11000 motor is 11.2 seconds.

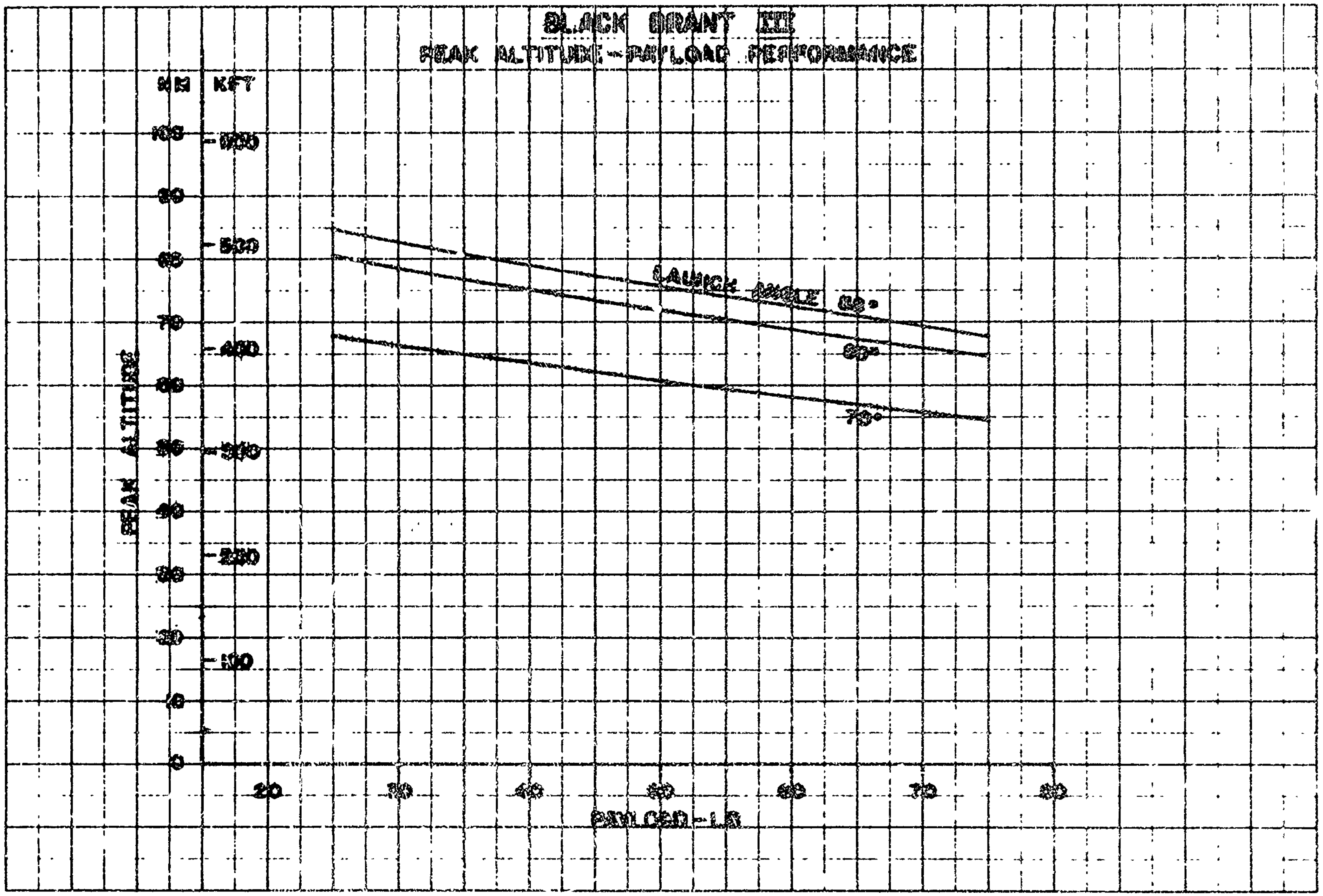
The Black Brant III is offered with several optional instrumentation packages: two different telemetry packages; quadraloop antenna; altitude sensing instrumentation and roll rate magnetometer.

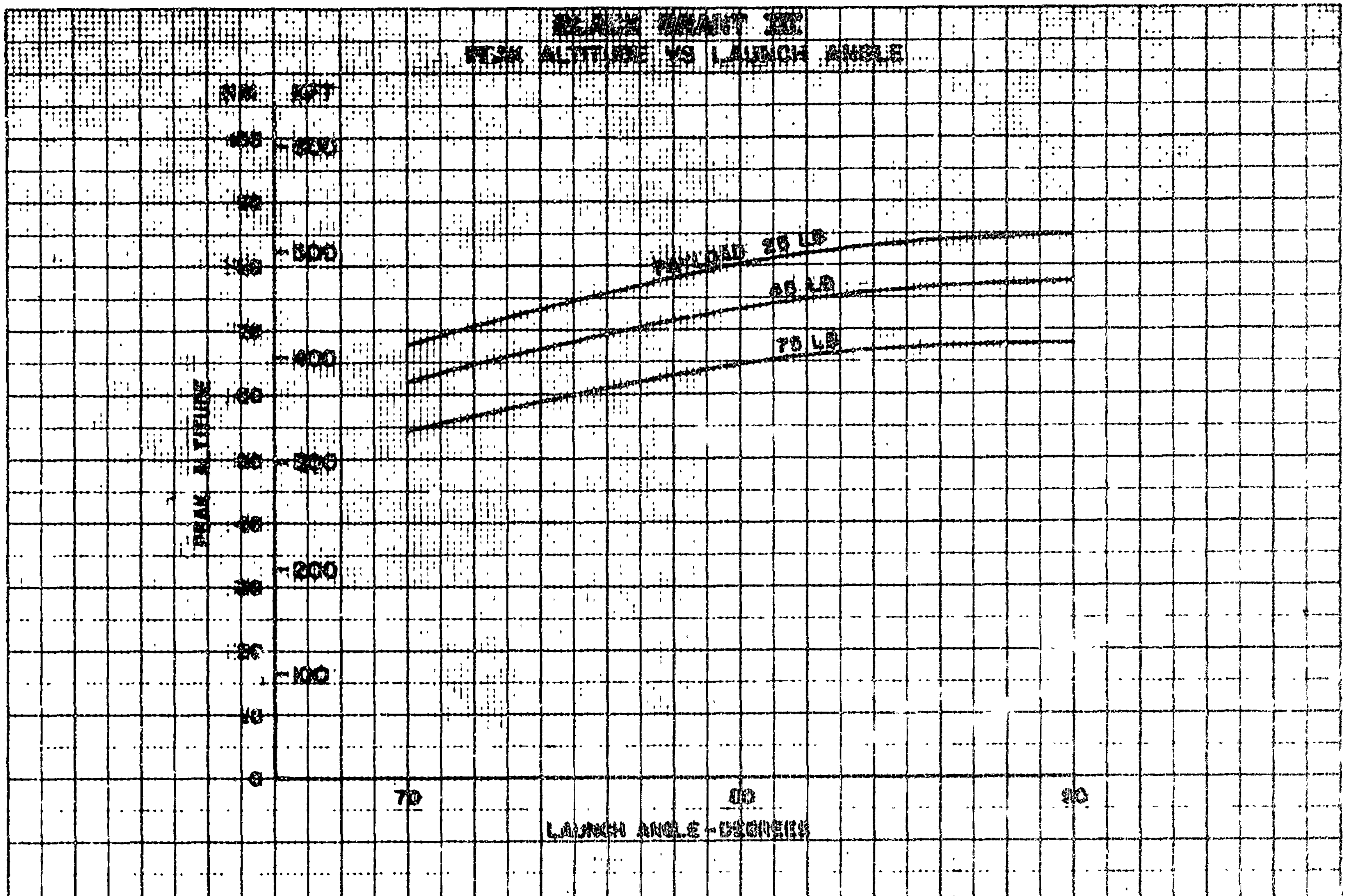
BLACK BRANT III
ASSEMBLY, DIMENSIONS AND WEIGHTS
PAYLOAD 25-75 LB

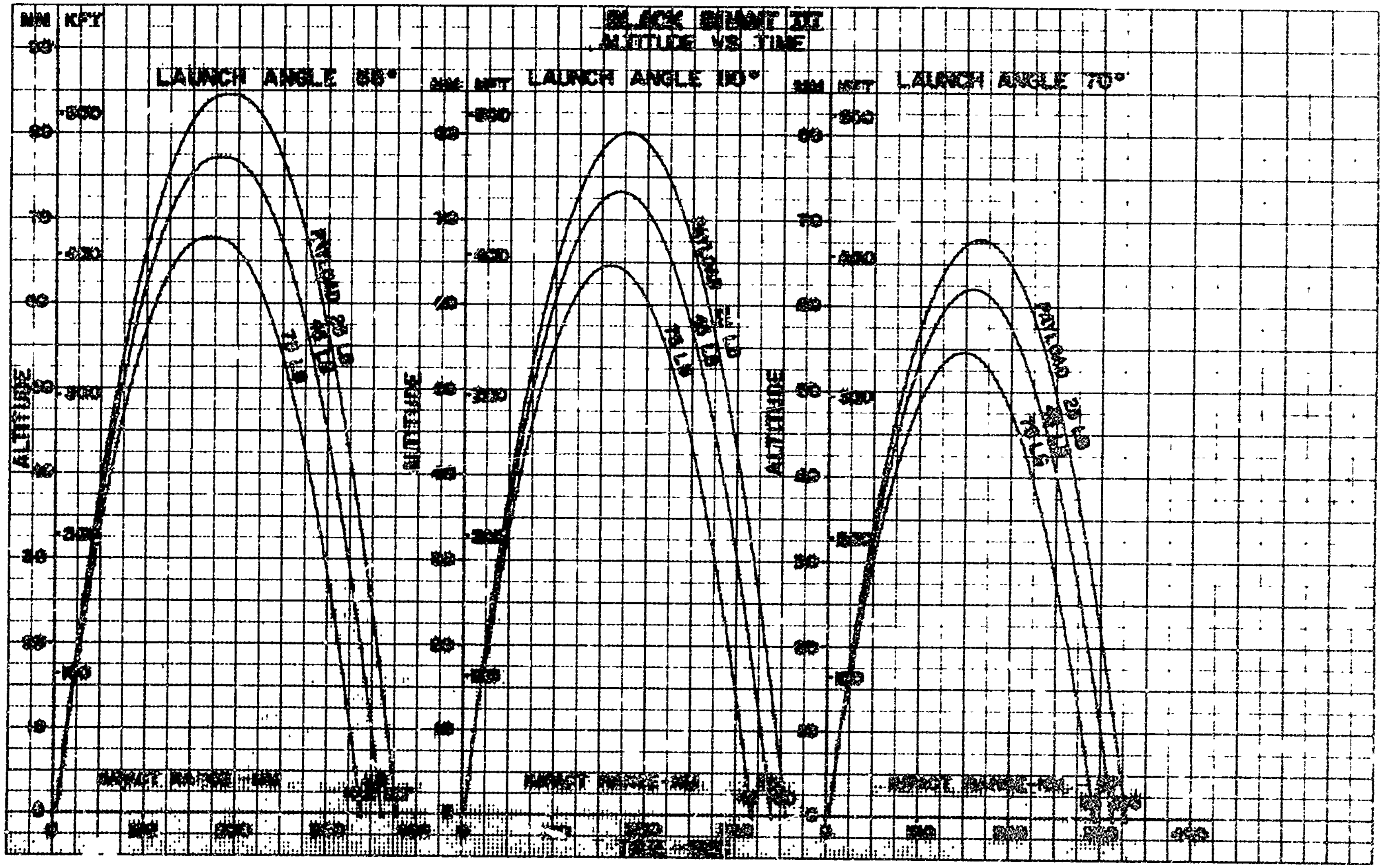


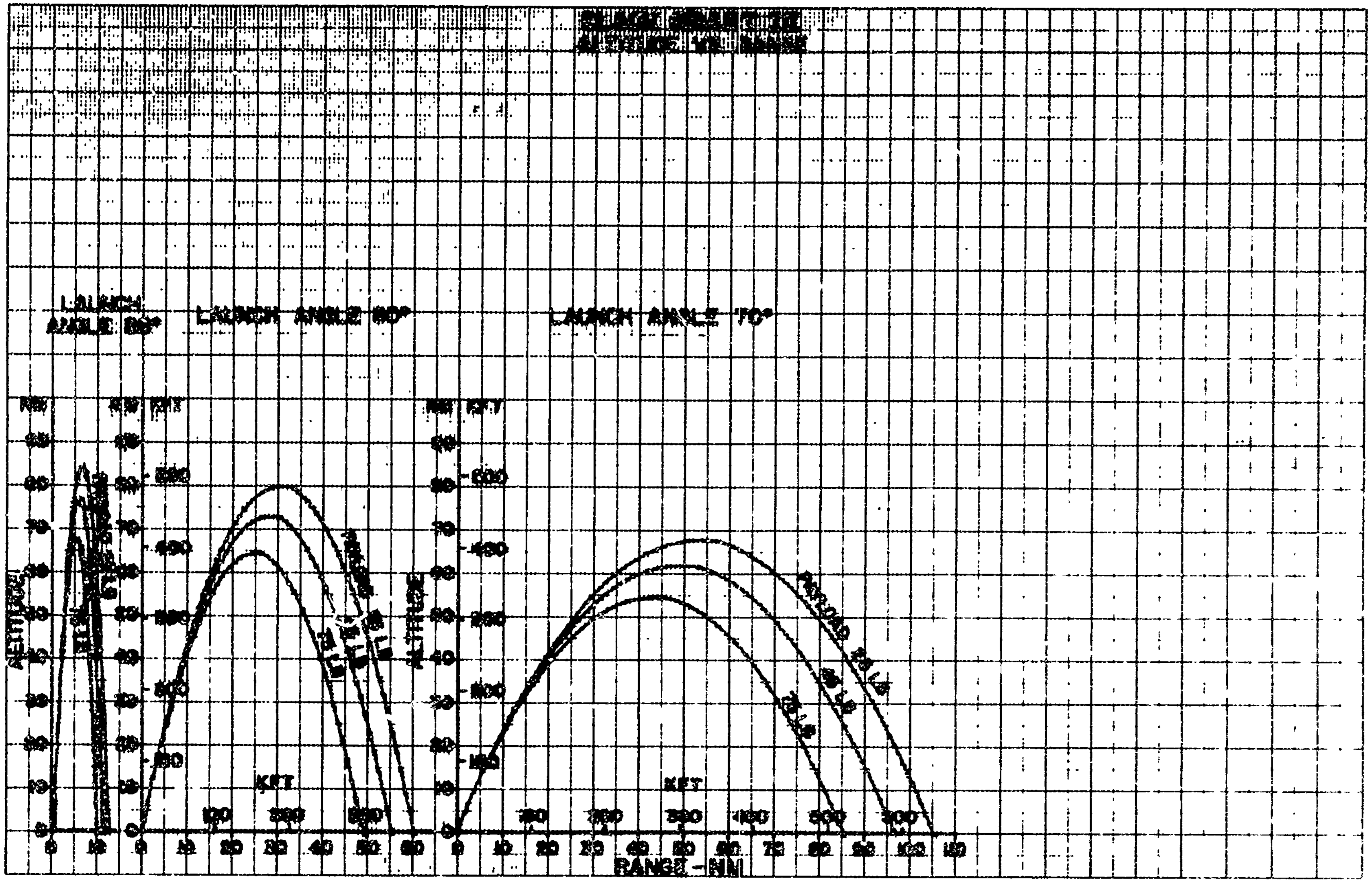
BLACK BRANT III
PAYLOAD COMPARTMENT



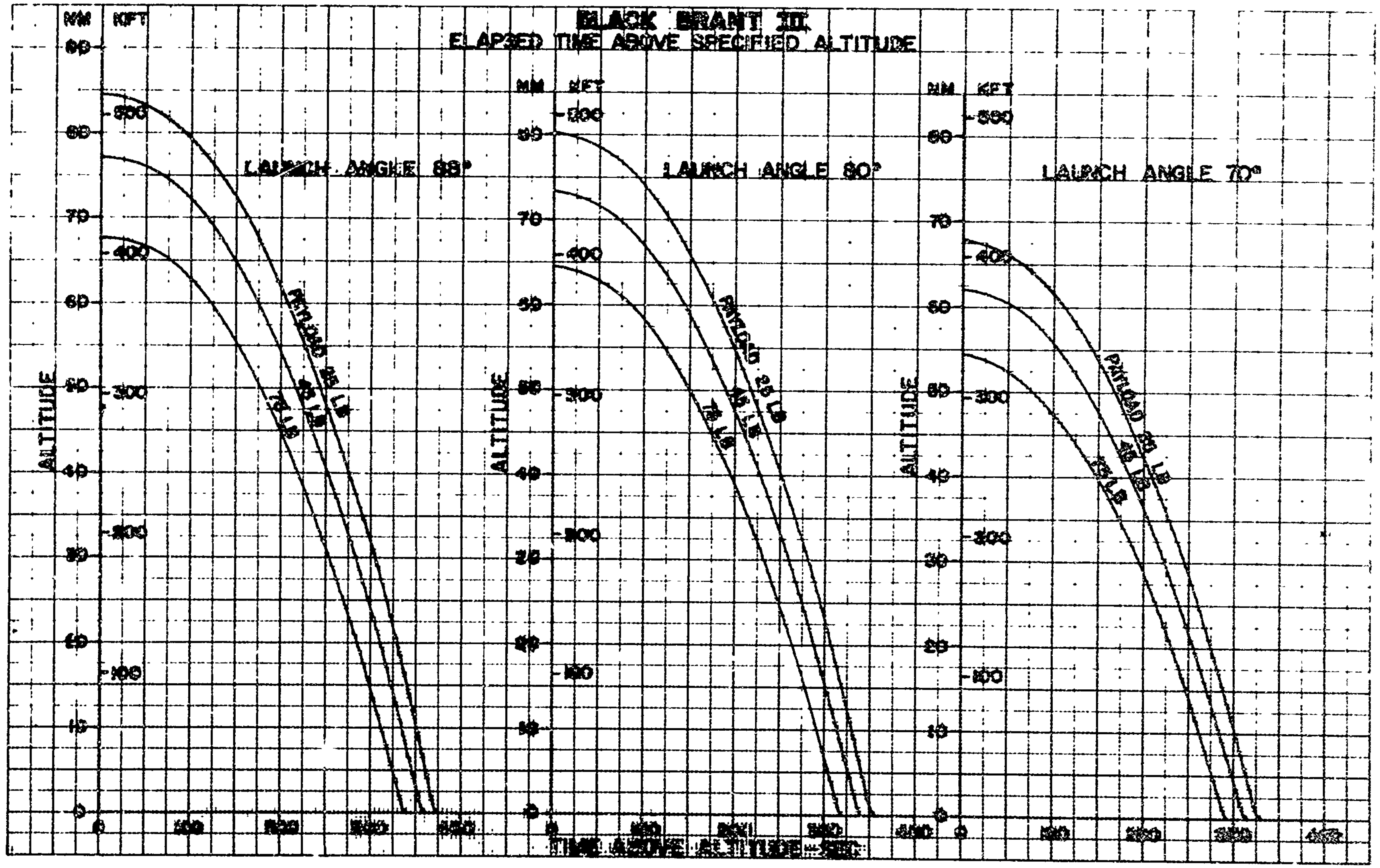

BLACK BRANT III
PEAK ALTITUDE - PAYLOAD PERFORMANCE
KM
KFT
100
90
80
70
60
50
40
30
20
10
0
600
500
400
300
200
100
LAUNCH ANGLE
20
30
40
50
60
70
80
PAYLOAD-LB
PEAK ALTITUDE

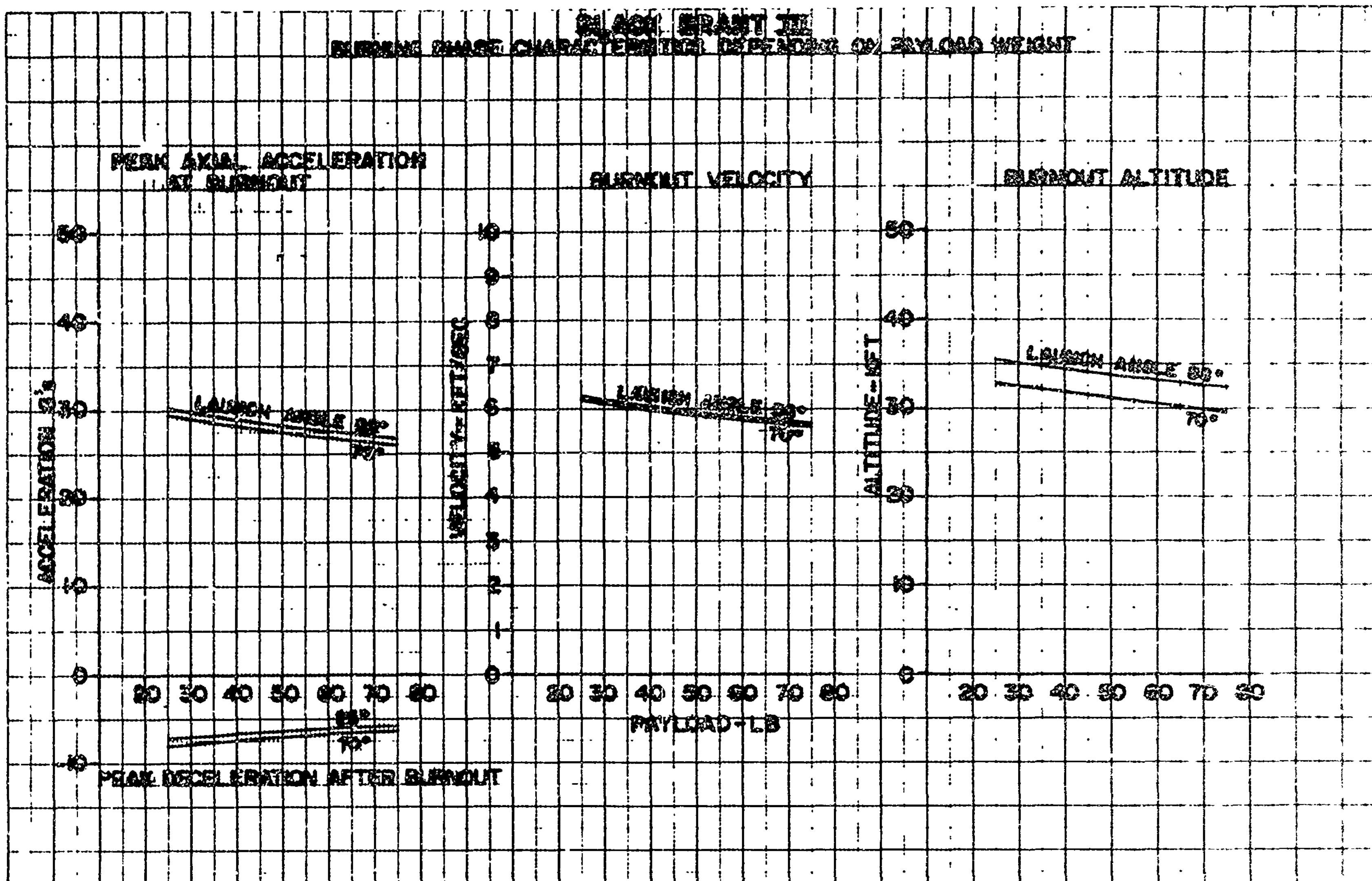

PEAK ALTITUDE VS LAUNCH ANGLE
NM
KFT
600
500
400
300
200
100
0
PEAK ALTITUDE
PAYLOAD 25 LB
45 LB
75 LB
70
80
90
LAUNCH ANGLE - DEGREES

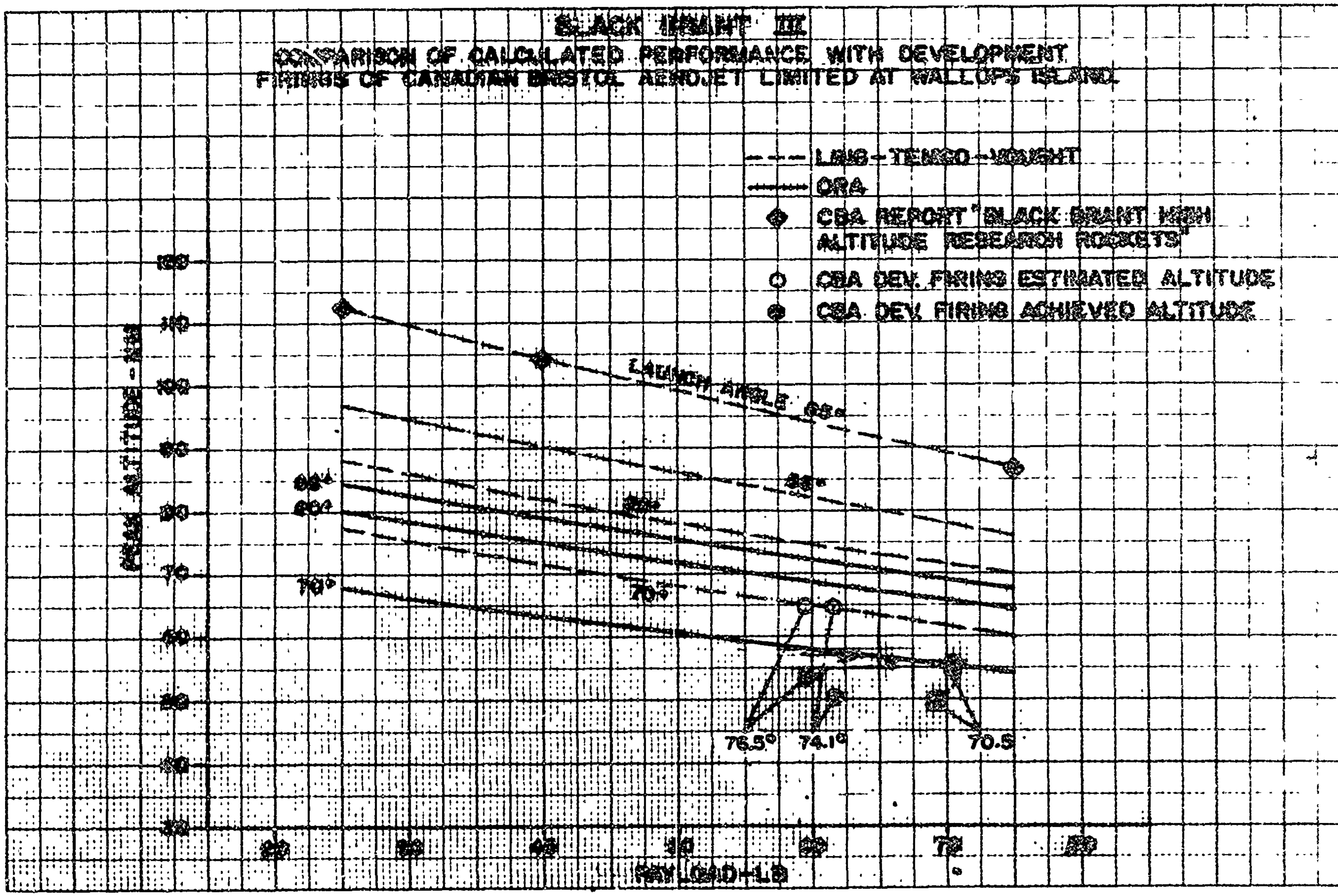

BLACK BRANT III
ALTITUDE VS TIME
LAUNCH ANGLE 85°
LAUNCH ANGLE 80°
LAUNCH ANGLE 70°
NM KFT
ALTITUDE
PAYLOAD 25 LB
46 LB
75 LB
IMPACT RANGE - NM


ALTITUDE VS. RANGE
LAUNCH ANGLE 80°
LAUNCH ANGLE 60°
LAUNCH ANGLE 70°
ALTITUDE
KFT
RANGE - NM
POUNDS 24 LB
48 LB
72 LB

13


BLACK BRANT III
ELAPSED TIME ABOVE SPECIFIED ALTITUDE
LAUNCH ANGLE 88°
LAUNCH ANGLE 80°
LAUNCH ANGLE 70°
PAYLOAD 25 LB
45 LB
75 LB
NM
KFT
ALTITUDE
TIME ABOVE ALTITUDE—SEC


BLACK BRANT III
BURNING PHASE CHARACTERISTICS DEPENDING ON PAYLOAD WEIGHT
PEAK AXIAL ACCELERATION AT BURNOUT
BURNOUT VELOCITY
BURNOUT ALTITUDE
ACCELERATION G's
VELOCITY - KFT/SEC
ALTITUDE - KFT
LAUNCH ANGLE 80°
70°
PEAK DECELERATION AFTER BURNOUT
PAYLOAD - LB
50
40
30
20
10
0
-10
9
8
7
6
5
4
3
2
1
20 30 40 50 60 70 80


BLACK BRANT III
COMPARISON OF CALCULATED PERFORMANCE WITH DEVELOPMENT
FIRINGS OF CANADIAN BRISTOL AEROJET LIMITED AT WALLOPS ISLAND
LING-TEMCO-VOUGHT
ORA
CBA REPORT "BLACK BRANT HIGH ALTITUDE RESEARCH ROCKETS"
CBA DEV. FIRING ESTIMATED ALTITUDE
CBA DEV. FIRING ACHIEVED ALTITUDE
LAUNCH ANGLE 65°
70°
76.5°
74.1°
70.5
PEAK ALTITUDE - NM
PAYLOAD - LB

BLACK BRANT III

GROUND SUPPORT EQUIPMENT

Launcher

The Black Brant III is rail launched. For the test firings at Wallops Island a modified Sergeant launcher with an effective rail length of 10.5 feet was used. Canadian Bristol Aerojet offers in addition its own launcher which rests on four out-riggers bolted to foundation points. The launcher can be transported to and used at different launching sites provided the foundation points are installed.

Handling Equipment

The handling equipment consists of holding fixtures, motor slings, work stands and fork lift. To fit the nose cone over the instrumentation compartment a special jig is necessary.

Electrical Support Equipment

Test equipment is required to check ignition squibs and circuits. For the checkout of the telemetry system a test console is necessary.

BLACK BRANT III

AERODYNAMIC HEATING AND HEATING OF PAYLOAD COMPARTMENT

The aerodynamic heating of the Black Brant III is more severe than that of the Aerobee 150 and Nike-Cajun because its propulsion phase takes place in a region of higher air density. (Burnout altitude approximately 30,000 feet, burnout velocity approximately 6000 ft/sec.) Therefore the payload compartment comes equipped with an ablative coating of three layers of phenolic reinforced fiberglass and additional internal heat insulation. No failures due to aerodynamic heating occurred during the test firings.

It should be noted that the aerodynamic heat input is only one of several parameters which determine the internal temperature of the payload. None of these parameters might be severe, however the summation of all can exceed toleration limits. Therefore internal heating should be checked for every different payload and launch condition.